Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING
FIVE DOLLARS A YEAR

JULY 1955

Hydraulic Pumps
for power transmission

Adhesive Bonding

Sheet Metal Beading

Speed Reducers

Extruding low-carbon steel—page 129

Cessna uses SIRVENE

PRECISION MOLDING SOLVES PUMP PROBLEM

It's licked: the problem of low efficiency in gear pumps at 1500 psi caused by hydraulic oil by-passing the gear teeth. Working from Cessna's unique design, C/R developed this Sirvene (synthetic rubber) gasket seal that equalizes the pressure of its effective areas with that within the gear chambers. It seals effectively at 1500 psi with temperatures up to 170° F., and would be suitable for pressures and temperatures above those encountered in operation. The extremely close tolerances to which this Sirvene part is made are vital to the pump's greatly increased efficiency and service life.

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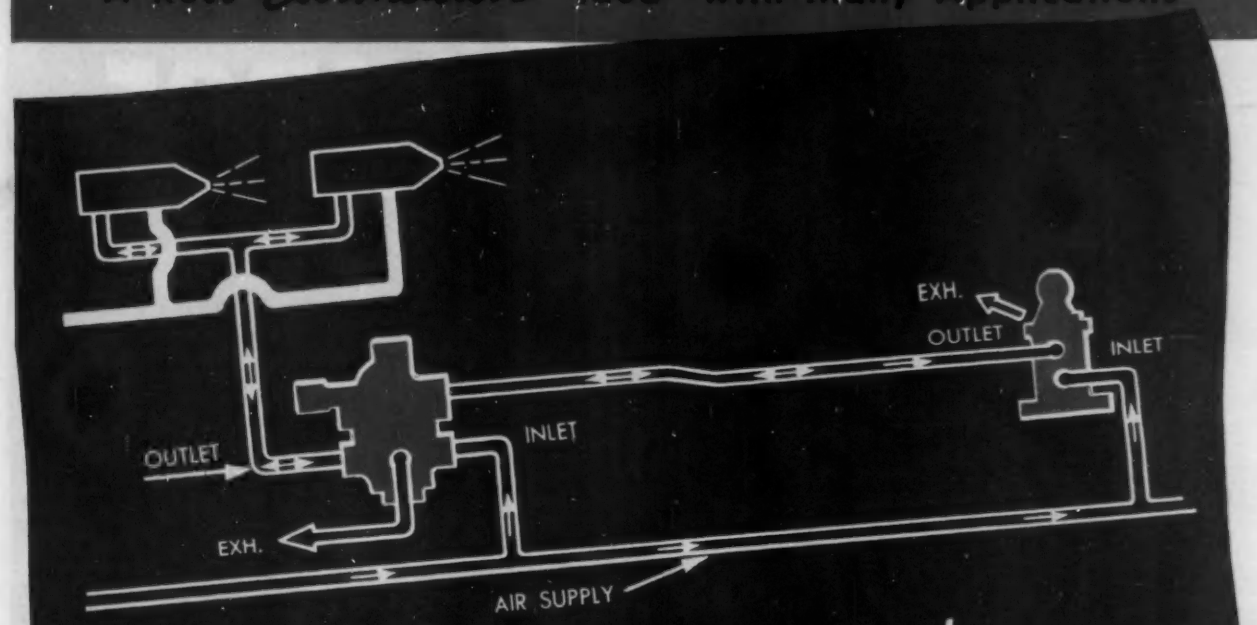
A Ross *Airmation* Idea—with Many Applications



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Ross OPERATING VALVE COMPANY

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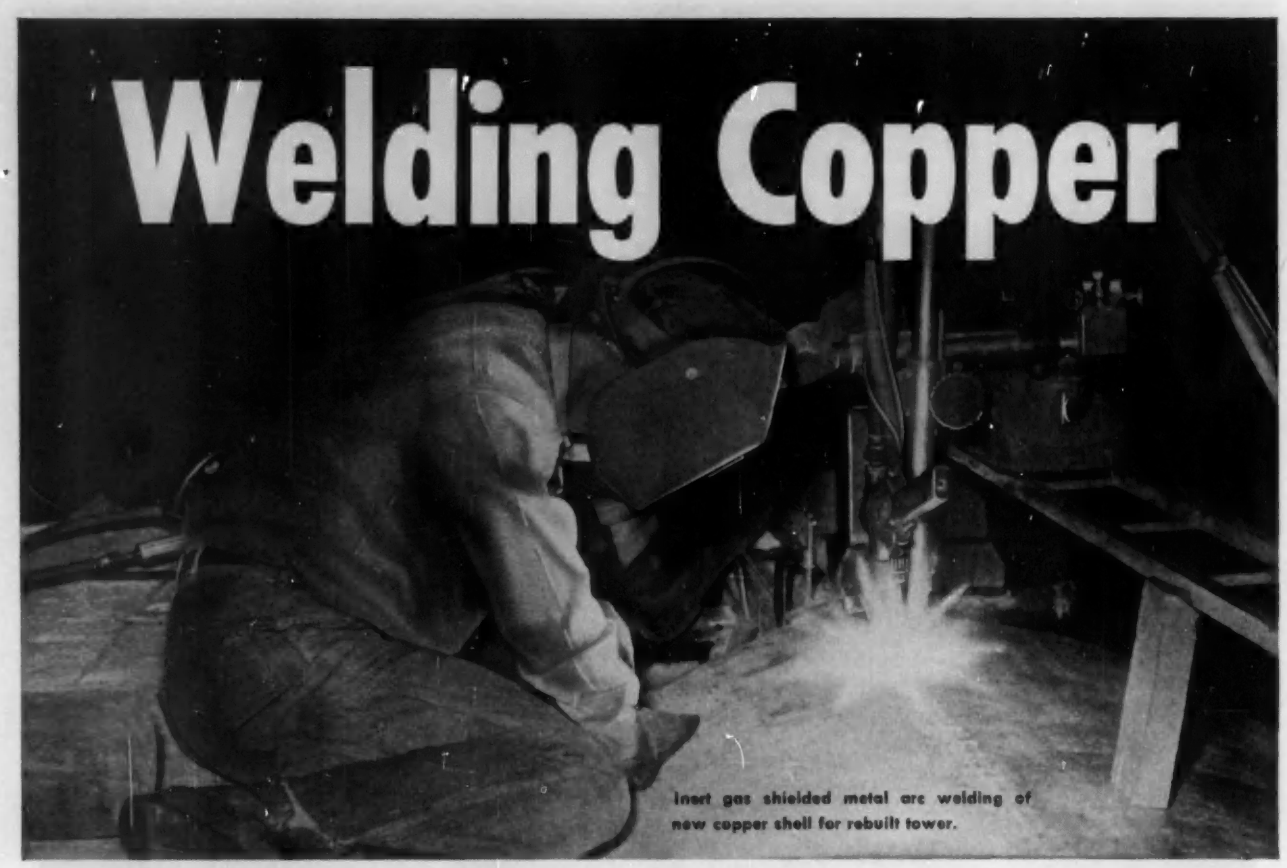
Welding Copper



Inert gas shielded metal arc welding of new copper shell for rebuilt tower.

SAVES 38% in materials and labor for joining

Some time ago, the Tennessee Eastman Company, Kingsport, Tennessee, a Revere customer, began to rebuild some of its copper stills or fractioning towers, which previously would have been silver-brazed. Revere's welding specialists were called in to see whether or not welding would be superior. Demonstrations were made to Tennessee Eastman engineers and shop personnel, with the result that welding was adopted. Actual experience in the shop shows a saving of 38% in materials and labor for joining, and a better job in every way. The welding method used is the inert gas shielded metal arc process.

Reconstruction of the towers was made to reduce the number of flanges. At the same time Tennessee Eastman changed from the flange joint tray construction to the inserted tray type and incidentally, reduced the number of gaskets with their accompanying maintenance problems. The trays are salvaged by shearing off the bolt hole circle and folding up the edges. The towers are some 45' high, 6' to 10' in diameter, with a tray or bubble cap plate at specified intervals. Tennessee Eastman plans to rebuild several towers a year in this economical way.

It will pay you as it did Tennessee Eastman to look into welding as a modern method of joining copper. Remember Revere is fully experienced in the most modern and efficient methods, and will collaborate with you on their application.

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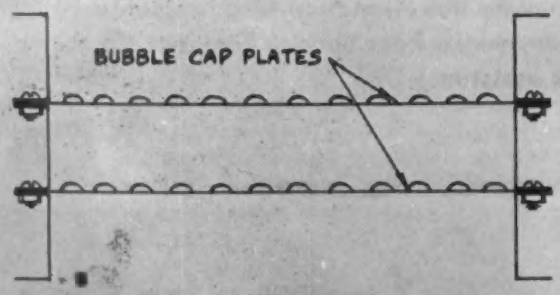
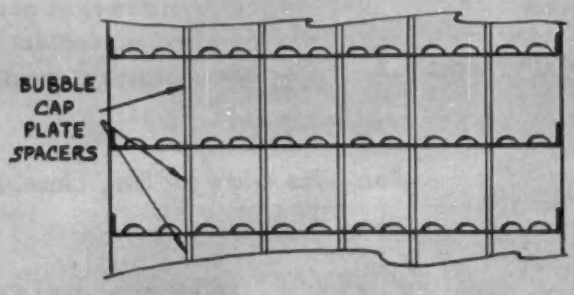


Section through old tower, showing bubble cap plates held in bolted flange.



Section through new welded tower. Bubble cap plates have had bolt holes sheared off, edges turned up. They are held in place by spacer rods.

Product Engineering

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Size limitations, cost advantages for limited quantities, physical properties and typical applications now possible with glass-lubricated billets.

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Relative performance and other factors influencing the selection of piston, gear and vane pumps for machine operation and control systems.

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New process gives increased uniformity of coating on intricate parts.

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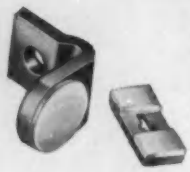
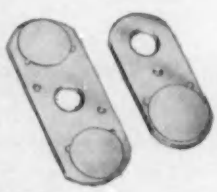
How do your contacts measure up to their jobs?





Are they under-designed...

or over-designed?

To be *right* for your needs, contact materials and contact designs must be evaluated in terms of *all* characteristics of the job they are expected to perform. Current and voltage in the interrupted circuit . . . nature of the electrical load . . . number and frequency of operations . . . contact gap and pressure . . . ambient temperature and atmosphere . . . and many other factors must be thoroughly considered, if contacts are to match both the performance and cost requirements of the application.

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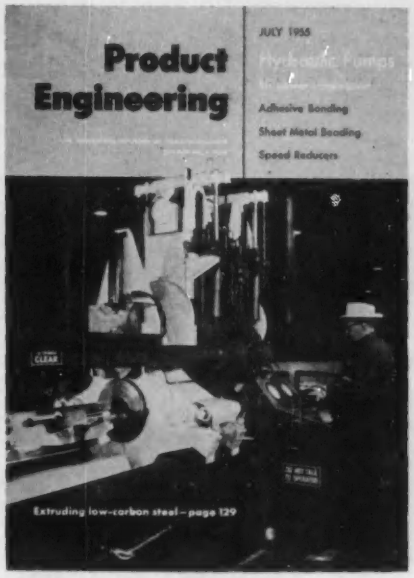

THIS MONTH'S COVER

Low carbon steel extruded at Jones & Laughlin Steel Corp. Billets are induction heated to 2350 F, rolled down a bed of powdered glass, and loaded into this 1000-ton Loewy hydraulic press. Molten glass serves as lubricant as ram forces metal through die. After straightening operation bars are cleaned and cold finished.

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Developments

To Watch

A SIMPLIFIED METHOD OF APPLYING CERMETS . . .

. . . .has been explored by scientists at the National Bureau of Standards, Washington 25, D. C., and results to date show that the coatings have good thermal shock resistance and are reasonably ductile. Ordinarily, cermets are applied as coatings by flame-spraying the material onto a metallic base. But with the NBS process, regular ceramic coating techniques have been used. A slip is prepared from cermet powder and a frit, and sprayed onto the base at room temperature. It is then fired at a temperature above the melting point of both the cermet and the frit. During the firing, the cermet particles melt to form a continuous layer that becomes brazed to the surface, providing a hard facing with good oxidation protection properties. Indications are that the type of cermet coating obtained depends mainly on slip composition and firing temperature. Firing time had little effect on the coating appearance. Firing in air gave good coatings on alloys that initially had good oxidation resistance, but a furnace atmosphere of low oxygen content was necessary to get good protection on such metals as molybdenum, ingot iron, and Sicromo 2. With one mixture, coating thicknesses from 0.004 to 0.008 in. were achieved with a single-coat application.

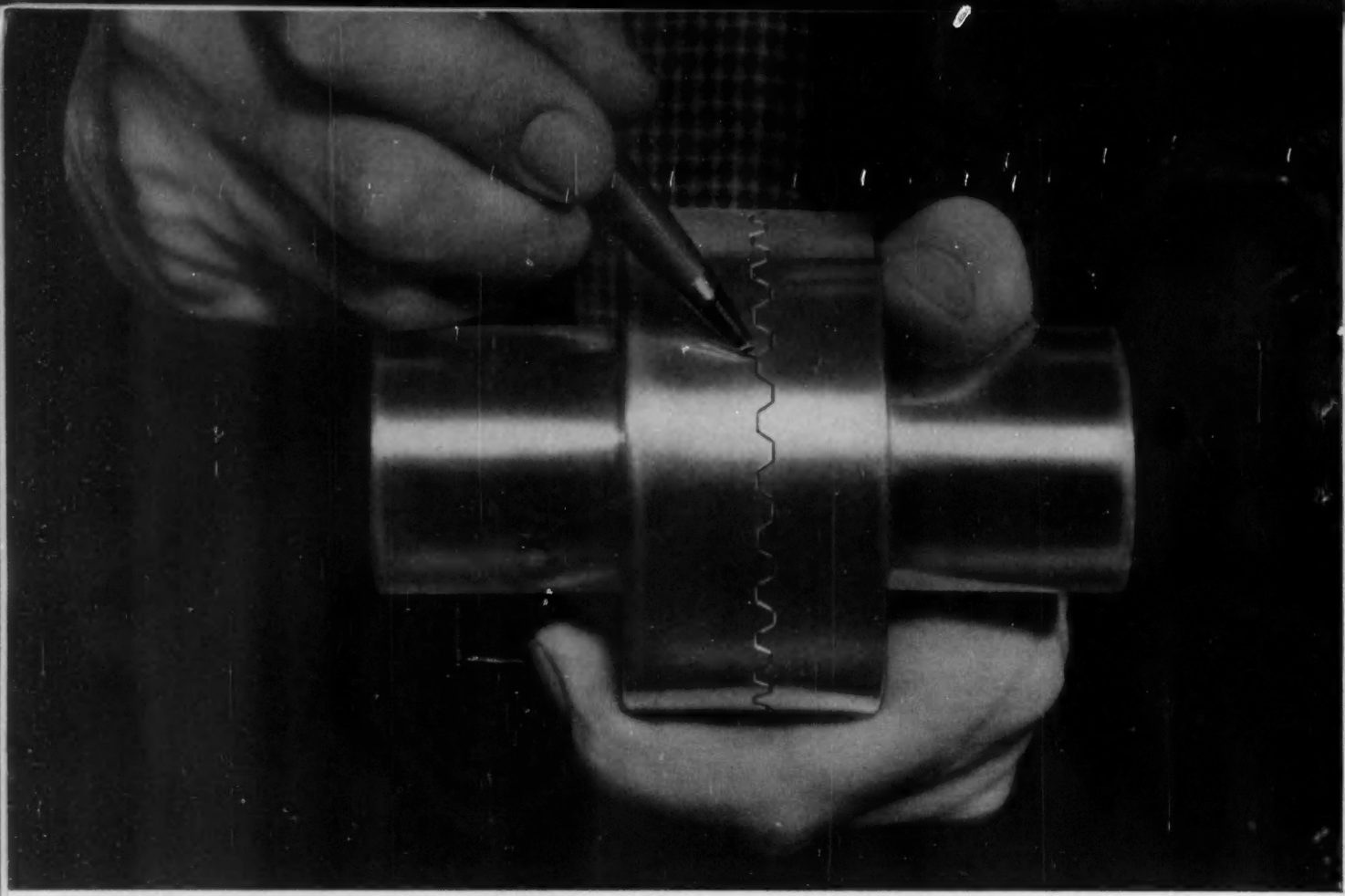
TRANSISTORIZED AUTOMOBILE RADIO. . . .

. . . .using only one-tenth the power needed for conventional car radios, has been announced by the Radio Corp. of America's Research Center at Princeton, N. J. The experimental model uses nine transistors and operates directly from the 12 or 6-volt battery. The unit needs no vibration power transformer, or rectifier. Meanwhile, Philco Corp. of Philadelphia, Pa., has announced that a similar radio of their design will be installed in the Chrysler and Imperial models late this year.

A CAPACITOR FOR HIGH TEMPERATURE USE. . . .

. . . .is designed to operate in ambient temperatures above 300 F, yet is not made of strategic materials. Developed jointly by General Electric's transformer and capacitor departments, the new capacitor is still in the advance development stage and is not yet commercially available. Designed for use in jet engine ignition systems, it is rated for use in the temperature range of 130 F to 390 F. However, tests at 500 F show that it has good characteristics for further development, particularly where voltage is about 2,000 v d-c. The high resistance to heat is obtained by using silicone treated mica mat as insulation, and by impregnating the capacitor with silicone oil. Size is 1–3/16 x 2½ x 4–¾ in., and weight is about one-half pound. General Electric, Schenectady 5, N. Y.

(continued on page 7)



This photograph shows tooth contact of a Curvic Coupling used in an aircraft drive shaft. The coupling simplifies the manufacture and assembly of this shaft and permits "in the field" maintenance.

CURVIC® COUPLINGS—*what they are and how they can help improve your product*

Curvic Couplings are precise face splines that drive, center and align parts with a high degree of accuracy.

They can improve your product by giving improved design, simplify maintenance through the use of interchangeable parts and lower production costs by eliminating the need for large complex parts.

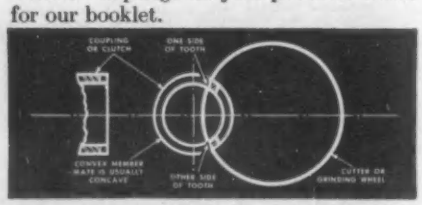
Because Curvic Coupling teeth curve lengthwise—either concave or convex—contact between the joining teeth is controlled. The load carried is equally distributed on all teeth as tooth-to-tooth spacing is held to extremely close limits. Therefore, Curvic Couplings can be made smaller, thinner and lighter than many other types of toothed connections.

Three principal types

1. *The permanent Curvic Coupling* is used for driving *and* aligning. It is for such uses as building up accurately balanced, precision rotors for jet aircraft engines. Curvic Couplings can hold mating parts within 0.0005″ total runout.
2. *The semi-universal Curvic Coupling* allows misalignment of shafts (2° maximum) together with axial freedom. Localized tooth bearing prevents load concentration on ends of teeth.
3. *Shift and overload Curvic Clutches* maintain proper tooth contact while the clutch engages and disengages. Shift clutches are used in washing machine wringer drives, motor trucks, outboard motors, aircraft —wherever a positive toothed clutch is needed.

Overload clutches are used where the amount of torque to be transmitted must be regulated, as in power screwdrivers.

The Gleason Engineering Department will be glad to consult with you regarding Curvic Couplings for your product. Write for our booklet.



The drawing above shows the method of producing both sides of Curvic Coupling teeth with the same surface of the cutter or grinding wheel, so that both sides have the same curvature. Curving the teeth lengthwise in this manner assures control of contact between joining teeth.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

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Developments to Watch

USING A BORIDE INSTEAD OF A CARBIDE BASE. . . .

. . . .a new cutting tool has been developed that is said to outperform the best carbides for machining steels. The tool material is made from titanium and boron powder, plus a binder, using ordinary powdered metallurgy techniques. The powders are put in a carbon mold, cold pressed, then the mold with the piece inside is placed in a high frequency coil and heated to over 2900 F. Tests have shown that wear life and cutting speeds are four times that of the tungsten carbide tool. Inventor of the process is Rand Development Corp., 12720 Lake Shore Blvd., Cleveland, Ohio.

DRY MAGNETIC PARTICLE CLUTCHES. . . .

. . . .are being studied by scientists at the Naval Ressarch Lab., Washington 25, D. C., in an attempt to improve upon the magnetic particle clutch using a liquid lubricant to hold the particles in suspension. About 40 combinations of powders have been tested with one mixture of three parts by volume of carbonyl "E" iron powder and one part zinc-oxide powder showing the best characteristics. Tested in a clutch operating with a clutching gap temperature over 750 F, there was no damage to the mixture, however, the bearings did not stand up at this temperature. Two other, but less satisfactory mixtures, were combinations of iron and boron nitride, and iron and silicon dioxide. The loading problem was solved by adding benzene to the mixture, injecting it into the gap, and allowing it to dry. In a bidirectional device built at NRL, the clutch output members could be reversed from no load, full speed in one direction, to no load, full speed in the opposite direction, in about 40 milliseconds.

RAISING THE TEMPERATURE LIMITS OF ALUMINUM. . . .

. . . .is underway, according to the Aluminum Company of America, Pittsburgh 19, Pa., who just announced their high temperature alloy called X2219. This new alloy is said to have good properties for extrusions and forgings at temperatures from 500 to 600 F, making it valuable for applications in and near aircraft and automotive engines. Also, in the final stages of development is a new alloy for sheet, plate, and extrusions for supersonic aircraft structures operating in the 300 to 400 F range. Tested at 600 F for 1,000 hrs, the X2219 alloy had a tensile strength of 18,000 psi and a yield strength of 14,000 psi. At the same temperature, this is compared to alloy 2218, a standard forging alloy used for high temperature applications which has a tensile strength of 6,000 psi and a yield strength of 3,500 psi.

HYDROGEN IN TITANIUM ALLOYS. . . .

. . . .has been linked to the premature failure of titanium alloy aircraft engine parts, according to the report of several scientists from the Materials Laboratory at the Wright Air Development Center, Dayton, Ohio. Studies showed that while the level at which hydrogen embrittlement becomes noticeable depends upon the alloy, difficulties will be reduced to a minimum if the hydrogen is kept below 125 parts per million. In alpha-beta titanium alloys, hydrogen contamination can cause low ductility in slow strain rate, room temperature, tensile tests, and early brittle fractures in room temperature stress rupture tests. Stress corrosion cracking at high temperatures is also caused by excessive amounts of hydrogen.

(*continued on page* 9)

Maximum Rust Protection

and a fine black finish for iron and steel

This long-wearing, rust resistant product is used on many types of iron and steel articles: Nuts and bolts, brackets, screws, nails, springs; tools, casters, padlocks, machine housings and castings; outdoor furniture, hinges, latches, ornamental iron.

Parco Compound is a versatile metal treatment. It is simple to operate, easy to control, dependable and uniform in results, and economical. It creates a dense coating of nonmetallic phosphate crystals over the whole surface of the article treated. There are no limitations on size or shape—any article which can be immersed in the tank can have this protection. Oil, wax, stain, or paint finishes may be used over Parco Compound, to produce maximum rust resistance with deep, velvet black appearance.

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BONDERITE and BONDERLUBE — aids in cold forming of metals

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Developments to Watch

STRONGER ALL-GLASS FIBER PAPER. . . .

. . . .with a tensile strength of more than 300 psi has been developed at the National Bureau of Standards, Washington 25, D. C., and is being studied for possible use as a filter of hot or corrosive fluids, a saturating or laminating base for plastics, electrical insulators in coil windings, and condenser and transformer cores. NBS says that the strength of this glass paper is compared to the 40 psi tensile strength paper developed in 1951. The higher strength is achieved by control of the acidity and temperature of the glass fiber suspension, and by changes in the mechanical handling of the fibers.

BETWEEN THE PERMANENT MOLD AND THE SAND MOLD. . . .

. . . .is where a new type carbon mold will find its best application. So far it has been possible to get 35 good castings from it. Engineered by the Rand Development Corp., Cleveland 10, Ohio, it is expected to be good for about 100 castings when the problem of oxidation of the molds is licked. A ceramic coating has been suggested here. The big advantage is that the carbon mold is made by regular powder metallurgy techniques using carbon powder and a fibrous binder. Another feature is that parts are easier to get out of this mold. Rand hopes to adapt the carbon mold idea to the manufacture of rocket nozzles which are now made from expensively machined graphite molds. Another big use is seen as a mold for titanium castings and cutting tool bits.

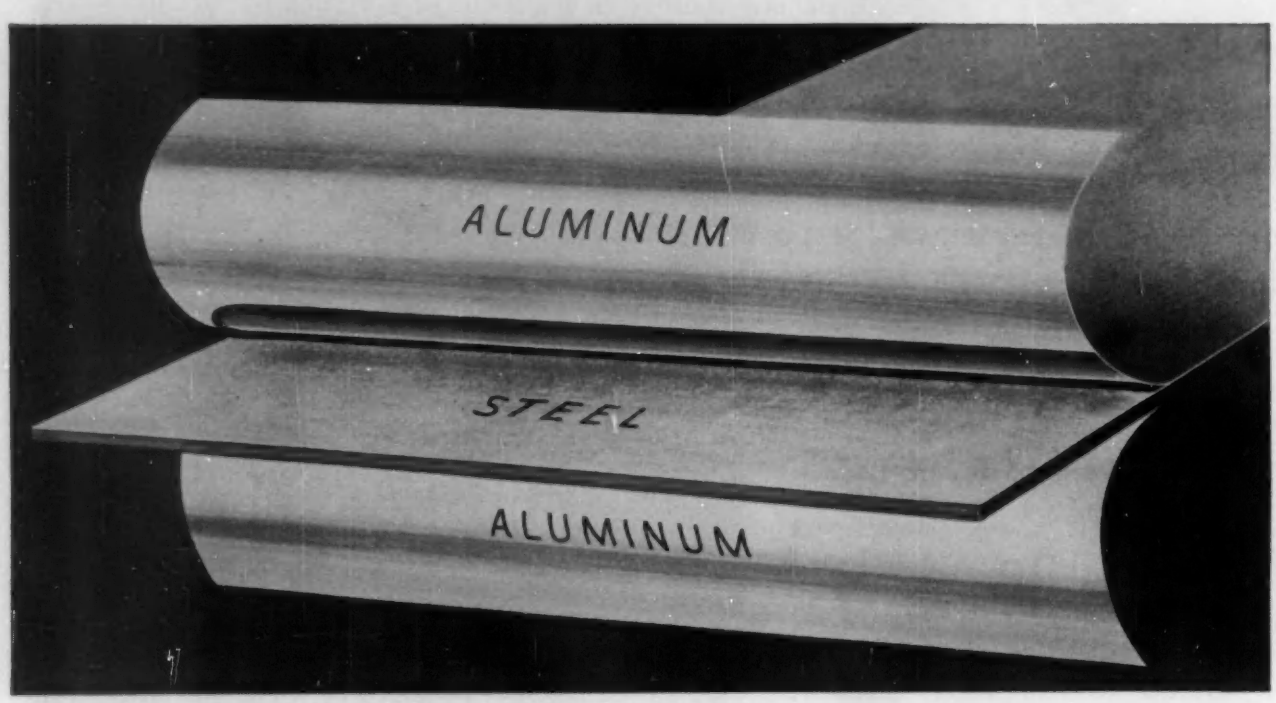
NEW TRANSISTORS WITH IMPROVED FREQUENCY RANGE. . . .

. . . .have been developed at General Electric's Research Lab. as a result of a better method of growing silicon crystals. Called the "meltback" process, transistors made by this method can operate efficiently at frequencies five times higher than ordinary transistors, and show improved power amplification characteristics. Current gains of several hundred are typical, and gains in the thousands have been achieved, as opposed to gains of 50 times in ordinary transistors. Key to the new process is the reduction in cooling time of the molten mass of the silicon material after it was formed. Cutting the cooling time from 20 min. to less than one second prevents the number of impurities from migrating from one layer of the material to another.

AND IN ADDITION. . . .

. . . .New type of silicone rubber, capable of remaining flexible at 600 F has been announced by General Electric Co.'s Silicone Products Dept., Waterford, N. Y.....Small, easy to operate spectrometer developed by Baird Associates, University Road, Cambridge 38, Mass., can be set up on foundry floor to analyze metal alloys; shows percentage concentrations of up to six elements .....Scientists in the Computer Lab. of the National Bureau of Standards, Washington 25, D. C., have packed up to 700 digital pulses per inch on magnetic tape, as opposed to 200-300 pulses per inch on old computers; answer is better developed circuritory to step up computation speed.....A power steering device for tractors and other of-the-road equipment is being produced by the Westinghouse Air Brake Co., 1943 Herman Ave., Wilmerding, Pa.; features of the unit are that it can be used on existing equipment without structural changes, and with no delicate adjustments to be made.

NEW Aluminum-coated Steel for rugged outdoor service



Armco ALUMINIZED STEEL (Type 2), made by coating sheet steel on both sides with molten aluminum, is your best bet for products used in outdoor service. Tests over a period of 15 years show that the atmospheric corrosion resistance of the new aluminum coating is at least 3 times that of the coating on commercial galvanized sheets.

This new product combines the great strength of steel with the corrosion resisting properties of aluminum. Yet, on the basis of equal thickness it costs less per square foot than solid aluminum. Besides that . . .

- - - - - - - -

- *It can be formed without flaking of the coating*
- *It reflects more than three-fourths of the radiant heat thrown against it*
- *It resists fire damage far better than metals with low melting points*

For complete information on this new aluminum-coated steel, just fill out the coupon and mail it to us.

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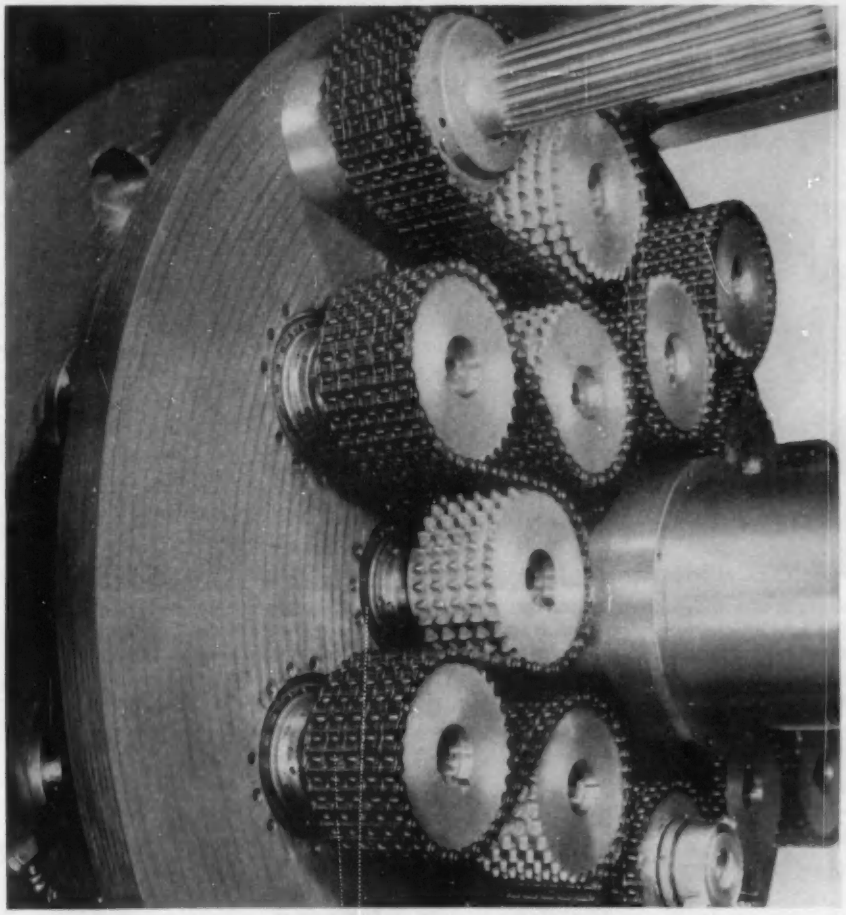
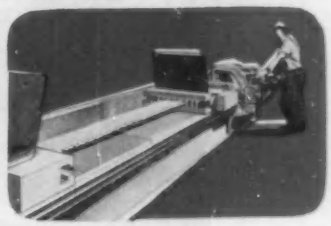
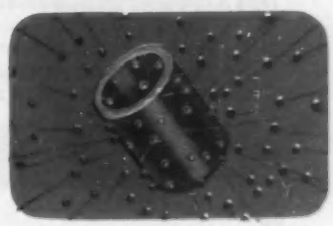
In roller chain... EXTRAS* like these give you extra reliability



LOCK-TYPE BUSHINGS (applied on a range of sizes) end a common cause of stiff chain.



PRE-STRESSING of multiple width chain provides uniform load distribution.



SHOT-PEENED ROLLERS have greater fatigue life, added ability to withstand impact.

* And you pay no premium for these LINK-BELT extras

THERE'S more to roller chain than just the parts you see. *Much more!* It's the hidden extras—standard on Link-Belt Precision Steel Roller Chain—that add up to better performance, longer life and greater dependability for your machines.

Check the three extras shown above. Then choose from the broad range of Link-Belt roller chains and sprockets: Single or multiple widths, ¼" through 3" pitch. Double pitch, 1" through 3".

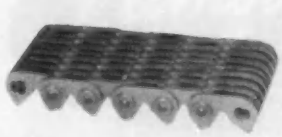
There's full ordering and application information in 148-page Data Book 2457. Ask your Link-Belt office for a copy today. Link-Belt's complete line of drive and conveying chains includes silent chain drives . . . all sizes and types of cast, combination, forged and fabricated steel chain.

LINK-BELT

CHAINS and SPROCKETS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 10.544

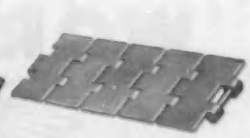
No one chain serves every purpose . . . get the RIGHT one from Link-Belt's complete line



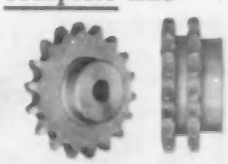
Silent Chain for high speed drives from fractional to thousands of hp. Available in wide range of pitches and widths in middle guide, duplex, non-flange and side flange types.

LXS Steel Chains, with offset or straight sidebars, are made to close tolerances. Ideal for rugged drives, conveyors.

Detachable Link-Belt chains, available in steel, malleable or Promal, for light-strength drives and conveyors.

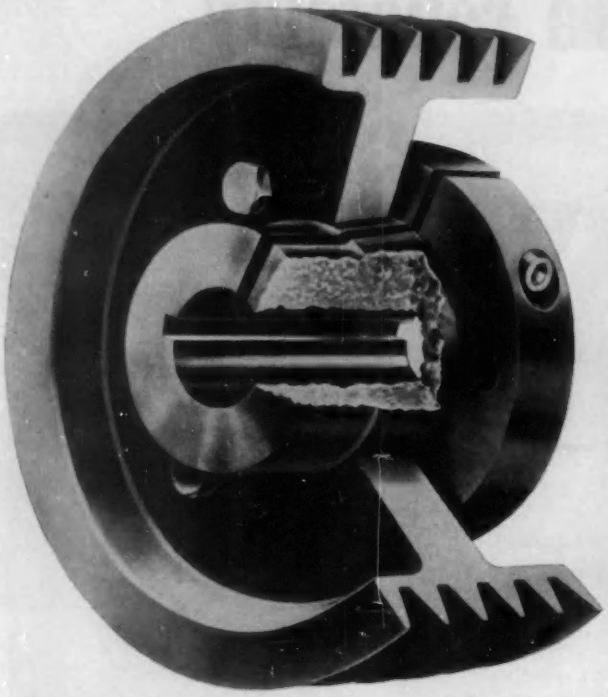


S-815 Flat-Top Chain—easy to detach and keep clean — one of complete line for carrying bottles, cans, cartons, cases, etc.



Complete line of single and multiple width cut tooth sprockets as well as a wide range of cast tooth sprockets.

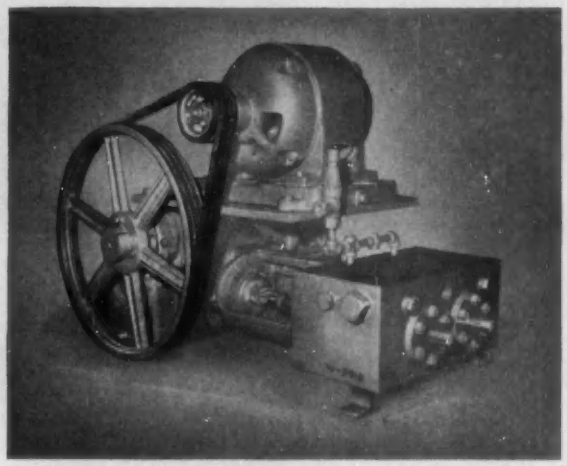
Why specify one sheave instead of another?



TAKE A CLOSE LOOK at this cutaway view of the Worthington QD — the *original* two-piece sheave. See how unique two-piece construction makes it easy to get on, easy to get off. But its heavy-duty split-tapered-cone hub grips shaft tightly, holds fast under the heaviest shock loads.

Some folks seem to think there's no difference between sheaves. No matter who makes them or sells them, a sheave's a sheave and a V-belt's a V-belt. Period.

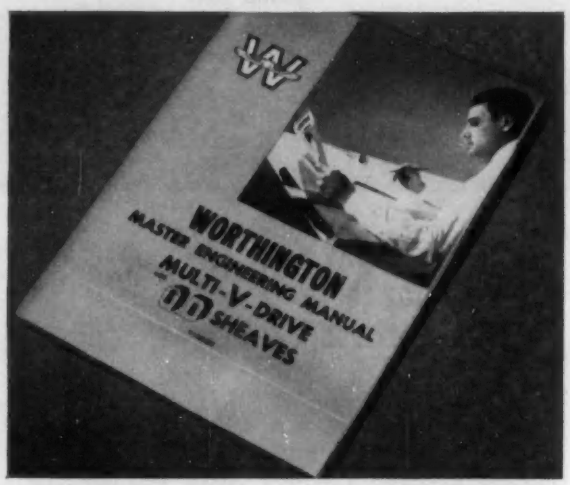
Not our users, though. They know *our* sheave (the Worthington QD) *is* different. More to the point, they know it's *better* than other sheaves. And easier to get, too. There are Worthington service outlets practically everywhere. Never any delays in stock shipment or service! MV.5.4



SCIENTIFIC DESIGN of QD sheaves not only provides more efficient transmission of power but actually adds to the looks of your product. What's more, I-beam construction of the QD drive sheaves provides greater strength with less weight.

WAREHOUSES LOCATED AT: Kearny, N.J. • Oil City, Pa. • Seattle San Francisco • Los Angeles • Denver • Tulsa • Ft. Worth • Houston New Orleans • Chicago • Cleveland • Atlanta, Ga.

PROMPT SHIPPING SERVICE. Thirteen factory warehouses with stocks covering over 100,000 V-belt drive stock combinations, from ½ to 600 horsepower, support over 250 stocking distributor outlets. These shipping centers can fill your requirements *fast*.



GOOD NEWS for engineers: This free, 100-page "Master Engineering Manual" makes sheave and V-belt selection as easy as falling off a drive shaft. Write for it today to Worthington Corporation, Mechanical Power Transmission Division, Section MV.5.4, Oil City, Pa.

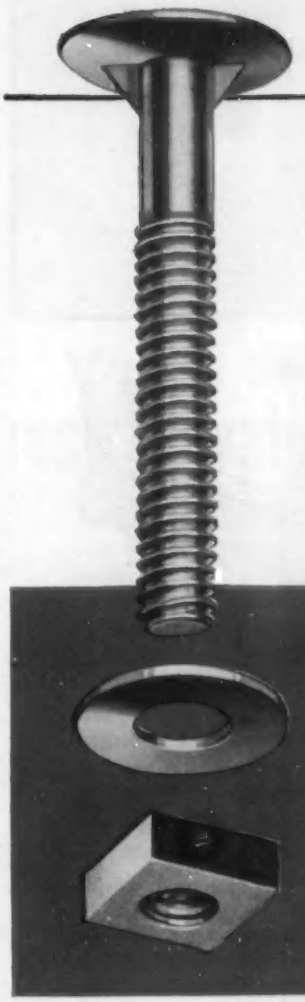
WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Compressors • Pumps • Multi-V-Drives • Variable Speed Drives

Wherever there's wood...

the new *Lamson* "W" BOLTS will set easier and Hold Better



This latest development of Lamson & Sessions is a flat head bolt of mild carbon steel . . . designed especially for fastening wood parts. The Lamson "W" Bolt "sets" easily without hammering, without crushing or splintering the wood fibre, and at less cost than Carriage Bolts.

The two sharp angle fins cut neatly into the wood and the large head draws up flush and square without imbedding thus permitting higher torques and stronger joints, especially in soft woods.

Get the full "W" Bolt story today on how to make wood assemblies look better, hold longer and at less cost than with any other type of wood bolting.

FLUSH FIT . . . NO IMBEDDING. The large diameter head with slight countersink prevents imbedding . . . the fins prevent rotation. Note photographic comparison to Carriage Bolt.
NO CRUSHING OR SPLINTERING. This feature prevents admission of moisture and resulting rot. The photo shows "W" Bolt and Carriage Bolt drawn up with equal torque.

HIGH-STRENGTH—Tests prove that the head and shank of the "W" Bolts are as strong as Carriage Bolts in every respect.

Lamson & Sessions

The LAMSON & SESSIONS *Co.*

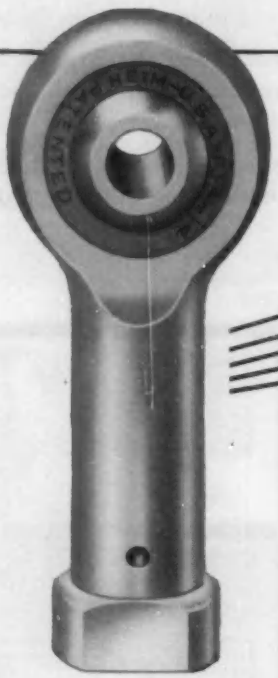
1971 West 85TH St. • Cleveland 2, Ohio

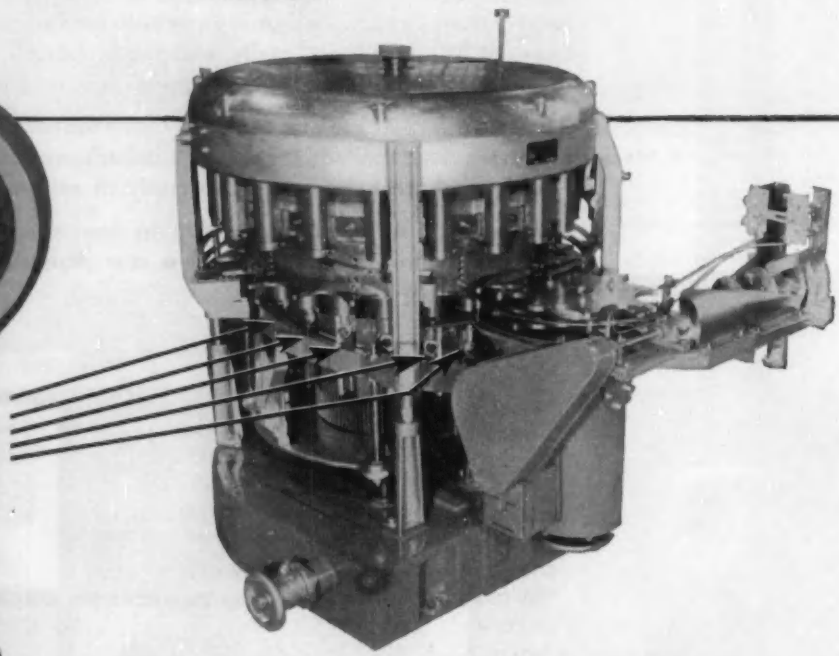
CLEVELAND AND KENT, OHIO • BIRMINGHAM • CHICAGO

HEIM *Unibal* ROD ENDS

contribute to cutting costs through plant modernization.

A dramatic feature of the modernization of the nation's packing plants has been the emphasis on speed as a means of minimizing production costs. The 30-pocket rotary filler for handling liquid or semi-liquid materials, made by the Sprague-Sells division of Food Machinery and Chemical Corporation, as an example of increased speeds, will turn out 650 five-ounce jars per minute. The downward stroke of the piston draws the product into the cylinder, the upstroke forces the material into the container. A closer look at this FMC filler shows a HEIM Unibal Rod End at each of the thirty stations, correcting misalignment where necessary and contributing toward the close accuracy of fill obtained by this machine.



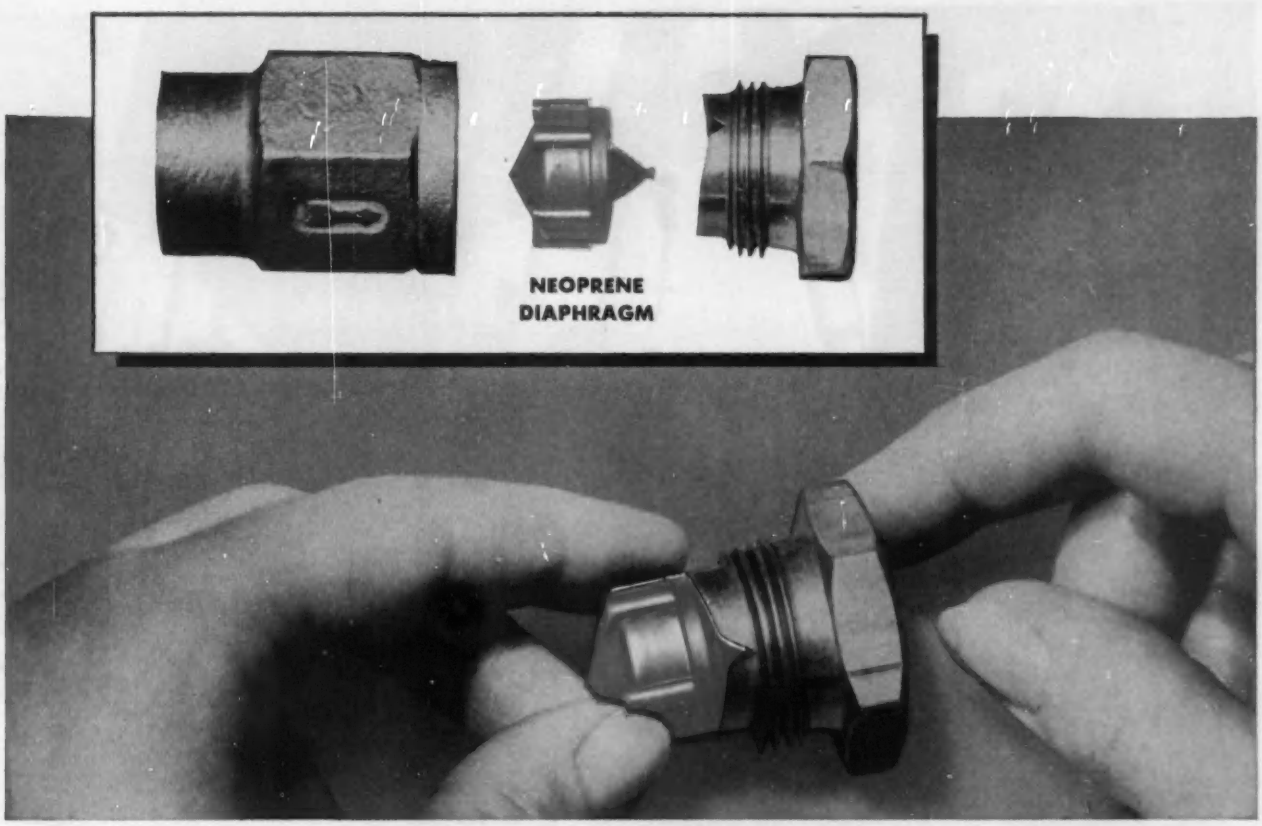


What is your Linkage problem

Perhaps HEIM
can help solve it
. . . or simplify it.

HEIM Unibal Rod Ends consist of a single ball through which the shaft or stud passes, bronze bearing inserts pressed around the ball, and a housing of steel or other specified materials. They correct misalignment in every direction, they reduce friction and lost motion in mechanical linkages, and they cost less than specially machined rod ends.

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT



Valve diaphragm of DU PONT NEOPRENE resists water absorption . . . stays flexible, resilient

This improved flow control valve assures a constant rate of water flow despite fluctuating inlet pressures. A neoprene diaphragm, specially compounded for low water absorption and a very stable modulus of elasticity, provides the controlling element in this device.

Designed for drinking fountains, washing machines, dishwashers, and other applications where constant rate of flow is a problem, the valve is simple and effective. Note the broad shallow V cut in the orifice (as well as the more obvious little notch). As inlet pressure increases, the neoprene diaphragm flexes into the broad V of the orifice, reducing the opening and throttling the flow. When pressure decreases, the diaphragm relaxes; the opening is enlarged; and the flow rate remains constant.

The valve is designed to maintain constant rate of flow (within ± 10%) at inlet pressures between 10 and 150 psi. in the temperature range between 50 and 150°F. The valve can be counted on to give dependable service indefinitely—thanks to neoprene, Du Pont's chemical rubber.

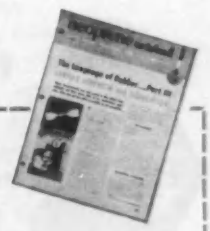
Next time your design calls for a resilient material, try neoprene. It has solved countless problems for designers over the years, and you'll find its reputation for trouble-free performance is well deserved.

Remember, of all resilient materials, only neoprene has balanced resistance to:

- Oils, solvents, most chemicals
- Permanent distortion
- Air and gas diffusion
- Abrasion, cutting, chipping
- Low-temperature stiffening
- Sunlight and weathering
- Oxidation
- Heat

NEOPRENE
The rubber made by Du Pont since 1932

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*



READ "THE LANGUAGE OF RUBBER"—A series of technical articles now appearing in each issue of the free NEOPRENE NOTEBOOK. Mail this coupon . . . add your name to the mailing list today!

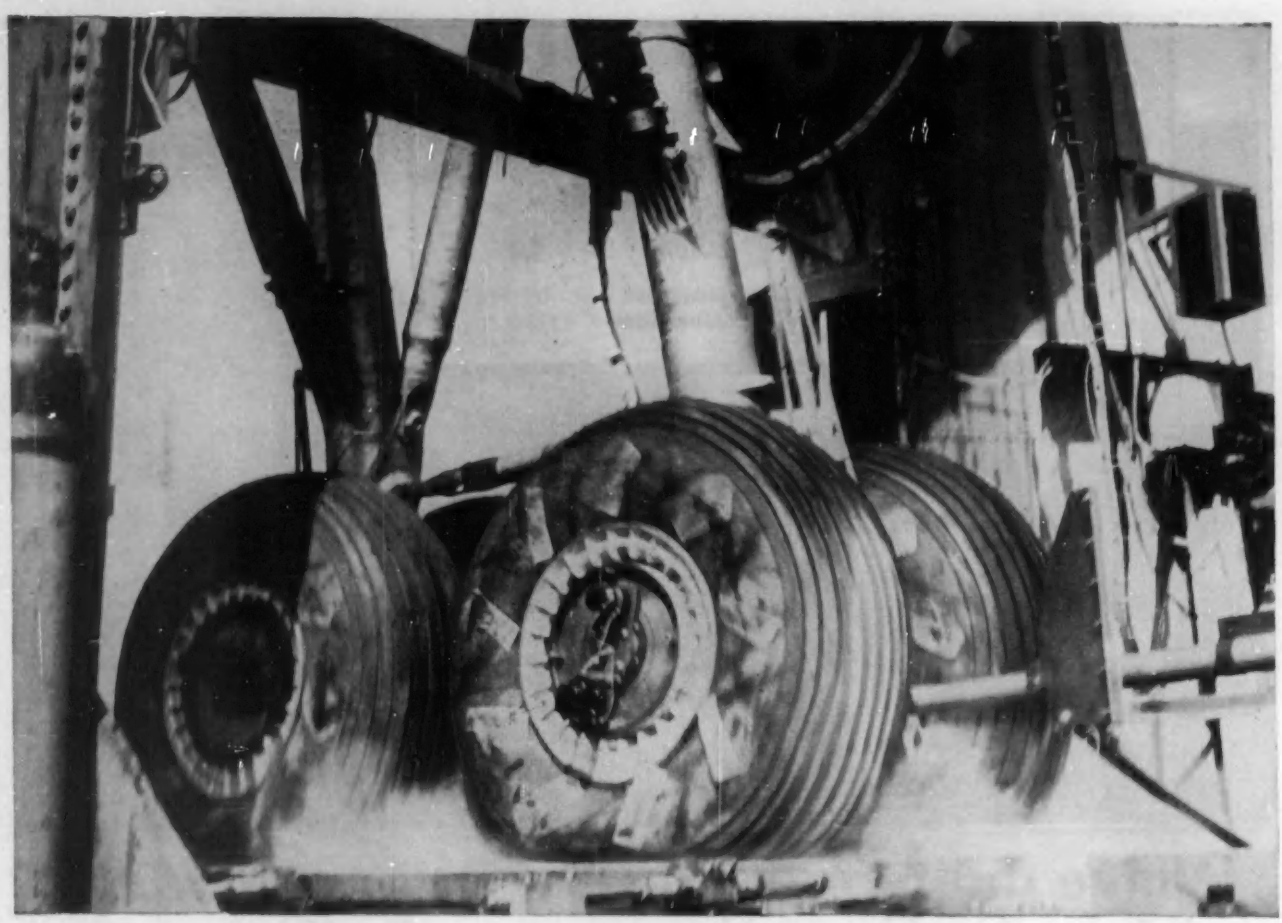
E. I. du Pont de Nemours & Co. (Inc.),
Elastomers Division PE-7,
Wilmington 98, Delaware.

*Name*_____ *Position*_____

*Firm*_____

*Address*_____

*City*_____ *State*_____



On TWA's SUPER-G Lockheed Constellation's landing gear . . .

Elastic Stop® nuts pass this brutal drop test

Like a bladeless guillotine, this 40-foot-high Lockheed test stand hoists landing gear assemblies aloft, spins their wheels backward 100 miles an hour, and crashes them down on its concrete base. Tons of lead weights simulate the big plane the landing gear is designed to carry.

The Lockheed experiments are directed toward development of lighter, stronger landing gear. These new units in turn demand fasteners designed for maximum resistance to fatigue failure plus the utmost dependability in terms of rated tensile performance and resistance to loosening under severe vibration and extreme shock and impact loads. Among the planes to benefit from data already secured by these punishing tests is the new Lockheed Super G Constellation, already placed in service by TWA. The Super G Connie's landing gear is only one of the many structural sections of the new plane fastened with vibration-proof Elastic Stop nuts.

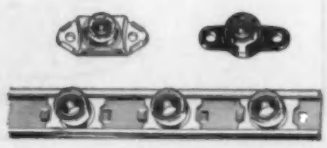
Elastic Stop nuts with their familiar red locking collars have been used on every new air frame developed during the last two decades. They have performed satisfactorily under the most unpredictable test conditions . . . under normal operating conditions . . . and throughout millions of hours of rugged combat service. You can rely on flight-tested Elastic Stop nuts!

ELASTIC STOP NUT CORPORATION OF AMERICA

Dept. N79-72 · 2330 Vauxhall Road · Union, N. J.

Red *Nylon* locking collars are standard on all ESNA fixed fasteners guaranteeing:

- vibration-proof locking
- thread sealing . . . no galling
- immediate identification
- adaptability to all shapes and sizes of aircraft fittings
- suitability to production line assembly methods
- extended reusability (ask for ESNA's high re-use Nylon Spec. #420).



Quick Lever Reset

Saves Time— Speeds Work

Added Evidence that—

Everyone Can Count on VEEDER-ROOT

Where time consumed in resetting is at a premium . . . on short machine-runs, inspection, military equipment and other applications . . . this new time-tested Quick-Reset Ratchet Counter is exactly the time-saving device you need. Just depress the easy-acting lever on the right side through 45° . . . *all 4 figures reset instantly to zeros.* And a thumb-lever may be used on the left side also if the counter is to be operated manually.

This compact, standard counter, now readily available from stock, is one of scores of Veeder-Root Counters (both standard and special) for manual, mechanical and electrical operation in every field from electronics to atomics. Just name what you want to count . . . and "The Name that Counts" will help you do the job. Write:

VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT

Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C.
Montreal 2, Canada • Dundee, Scotland
Offices and Agents in Principal Cities

"The Name that Counts"

LESS TORQUE

In leather—NATIONAL MICRO-TORC
TRADEMARK

Lowest torque • Highest lubricity • No measurable leakage
Runs cool, lasts longer • Sealing lip stores oil

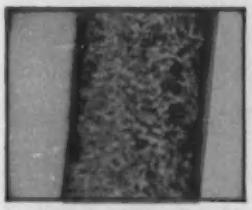


Fig. 1. National Micro-Torc Oil Seal. Oil cannot pass through elastomer coated side. Inner body retains natural porosity for "oil storage".

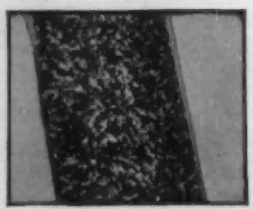


Fig. 2. Leather seal completely impregnated with rubber. Natural porosity of leather is destroyed by intense impregnation.

Shaft Size	Break Away Torque		Running Torque	
	Conventional Leather	Micro-Torc	Conventional Leather	Micro-Torc
1.500"	39 oz-in	7 oz-in	60 oz-in	56 oz-in
2.937"	126	39	253	164
3.812"	95	49	287	207

Fig. 3. Breakaway and running torque measurements, National Micro-Torc vs. conventional leather oil seals.

	NMB Micro-Torc		Completely Impregnated Leather Seal	
Test Conditions				
Shaft Speed:	2200 RPM		800 RPM	
Shaft Size:	3.875"		2.750"	
Shaft Runout, TIR:	.003"		.004"	
Oil Temperature:	200° F.		165° F.	
Test No.	C-1642	C-1643	D-100	D-101
Total Running Time:	1017 hrs.	1017 hrs.	108 hrs.	108 hrs.
Condition after Test:				
Sealing Member:	Flexible	Flexible	Very Stiff	Very Stiff
180° Bend Test:	Surface Cracks	Surface Cracks	Deep Cracks	Deep Cracks

Fig. 4. Service life test results. National Micro-Torc Oil Seals vs. completely impregnated leather seals.

Revolutionary new Micro-Torc Oil Seals, exclusively from National, employ a leather sealing member coated on the surface with a high lubricity elastomer. This coating not only reduces torque as much as 80% but effectively prevents lubricant leakage. Since the coating is applied to the outer surface of the sealing member only, the body of the sealing lip retains its natural porosity to store oil for periods of semi-starved operation. (Figure 1.)

The appreciable superiority of Micro-Torc over completely impregnated leather seals (Figure 2) is shown at left. In addition to a marked reduction in torque (Figure 3), service life of Micro-Torc seals was test-proven to be up to 10 times the life of completely impregnated seals, and 2 to 3 times that of wax or resin impregnated seals. (Figure 4.)

In dry-running life tests Micro-Torc seals operated for 100 hours at 1,350 rpm *with no lubrication*. No squealing or sloughing was experienced, and all Micro-Torc seals remained flexible and operative.

National Micro-Torc Oil Seals are recommended for application where temperatures do not exceed 200° F, shaft speeds are not over 2,000 fpm and runout is not greater than .010 indicator reading. For minimum torque, cool operation and long life in leather oil seals, specify National Micro-Torc. Write or telephone nearest National Applications Engineer for complete information.

New! NATIONAL TORQUE METERS

New National Torque Meters provide a simple, accurate way to measure torque of oil seals. The meters are rugged, compact, easily portable, ideal for production line or receiving department. They have an easy-acting self-centering chuck for accurate seal holding, and use a simple taper-fitting test shaft you can make up in a matter of minutes. The Meters are designed for utmost simplicity, and with them unskilled personnel can make accurate torque readings with but a few moments training.

Two sizes: Model 615 fits seals up to 6" dia.; 15 lb. in. torque. Model 845 fits seals up to 8" dia.; 60 lb. in. torque.

Meters measure approximately 13" long x 10" wide x 11" high, weigh about 27 lbs. Sturdy carrying case can be furnished.

with NATIONAL OIL SEALS

In synthetic rubber—SYNTECH®

Low torque • Rubber-covered or ground O. D. • Long life
Zero leakage • Unaffected by most industrial fluids

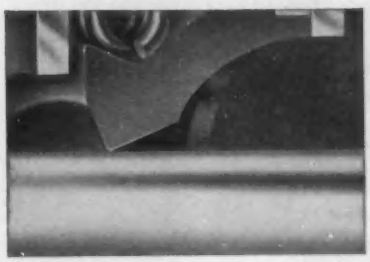


Fig. 5. Cross-section, typical National Syntech sealing lip. Note limited point of contact between seal and shaft.

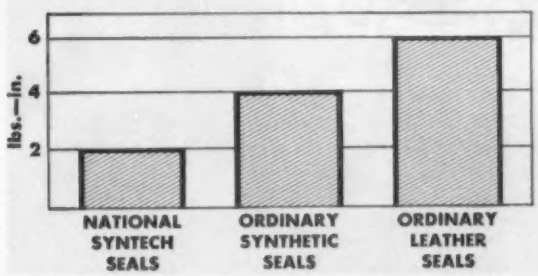


Fig. 6. Torque, Syntech vs. conventional synthetic rubber and leather oil seals. Seals tested on same shaft, under identical conditions.

Fig. 7. (Left) National Syntech Rubber-Covered O.D. (Right) National Syntech with machine-ground steel O.D.

NATIONAL
OIL & GREASE SEALS
O-RINGS SHIMS

Developed and introduced by National in 1946, National Syntech seals are among today's most widely used synthetic rubber oil seals. Their performance and dependability have been proven in thousands of commercial applications.

Syntech seals are particularly designed for higher speed, higher temperature applications where torque must be held to the absolute minimum. They feature an exclusive sealing lip design (Figure 5) which insures minimum contact between lip and shaft, yet provides zero leakage over a long service life. The marked difference in torque between Syntech and ordinary leather seals can be as much as 200%, as shown in Figure 6.

National Syntech Oil Seals are available in a wide selection of types and sizes, including seals with rubber covered or machine-ground peripheries (Figure 7) spring-tensioned or spring-less, or with twin or triple lips for special applications.

Call in a National Applications Engineer

CHICAGO, ILL. . . . *Room 4113 Field Building, FRanklin 2-2847*
CLEVELAND, OHIO . *210 Heights Rockefeller Bldg., YEllowstone 2-2720*
DALLAS, TEXAS . . . *30½ Highland Park Village, JUstin 8-8453*
DETROIT, MICH. . . . . *726 Lothrop Avenue, TRinity 1-6363*
DOWNEY (Los Angeles Co.), CALIF. . *11634 Patten Rd., TOpaz 2-8166*
INDIANAPOLIS, INDIANA . *2802 North Delaware St., WAlnut 3-1535*
MILWAUKEE, WIS. . . *647 West Virginia Street, BRoadway 1-3234*
NEWARK, N. J. . . *Suite 814, 1180 Raymond Blvd., MItchell 2-7586*
REDWOOD CITY, CALIF. . . *Broadway and National, EMerson 6-3861*
WICHITA, KANSAS . . . . *519 South Broadway, WIchita 2-6971*

MORE INFORMATION?

NATIONAL MOTOR BEARING CO., INC.
DEPT. A., REDWOOD CITY, CALIFORNIA

Please send complete information, illustrated technical details on
_____Micro-Torc seals _____Syntech seals _____Torque Meter

Name_____

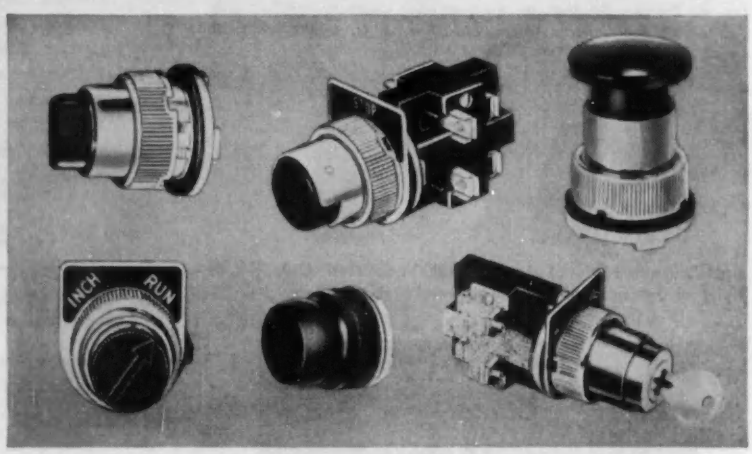
Company_____

Street_____

City_____ Zone____ State_____

3310

Westinghouse 6-Unit Oil-Tite* Control Station



Greater Unit Flexibility for Oil-Tite pushbuttons is provided by many types of operators. Oil-Tite controls available in one to twelve unit stations. The die-cast gasketed oiltight enclosure is impervious to water, oil, coolant, cutting compounds and dust.

Here's why Westinghouse control stations increase pushbutton flexibility

Industry's Most Complete Line offers a wide selection of components for every pushbutton application—standard duty, heavy duty, oiltight, pendent type and special service.

Standardized Components provide greater application flexibility—help you benefit from off-the-shelf shipments and smaller inventories. The simple combination of a few interchangeable component parts gives you the right pushbutton or selector switch for every application or service requirement.

Special Features like these save you time and money: double-break, solid silver contacts—complete selection of interchangeable operators—large buttons for easier, more certain operation—shroud shielded buttons protect against accidental operation—double knockouts, top and bottom, for easier wiring—finest available materials.

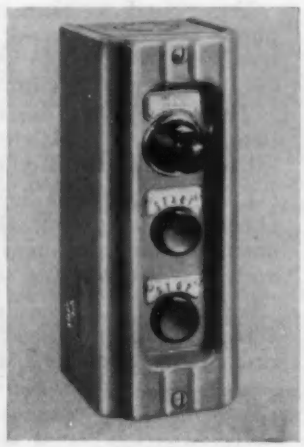
Enclosures for Every Application—surface or flush mounting, indoor or outdoor, water and dust-tight, oil immersed, die-cast gasketed oiltight, and pendent mounting.

Why not investigate the advantages of standardizing on all your pushbutton needs with Westinghouse control stations? Get the full story from the control sales engineer at your nearest Westinghouse office, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-30189

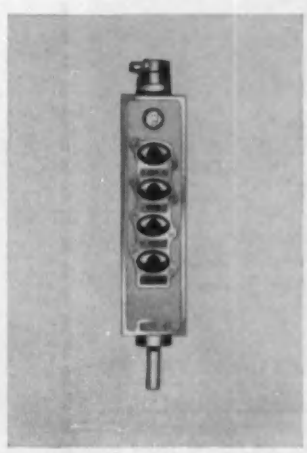
*Trade-Mark

YOU CAN BE SURE... IF IT'S Westinghouse

Standard-Duty pushbuttons are available in a choice of one-, two- and three-unit stations.



Heavy-Duty surface mounting stations offer a variety of enclosures—a wide range of accessories.



Pendent-Type stations are available in standard, heavy-duty and Oil-Tite enclosures.

Special-Service pushbuttons available for mining, steel mill and other extra-heavy-duty applications.

This Steel keeps these outdoor phone

Republic Electro Paintlok

Year-round weather is mighty rough on outdoor phone booths. To make them practical from a maintenance standpoint, as well as continually attractive, a durable, long-lasting finish is a must.

That's why the Sherron Metallic Corporation of Brooklyn, New York, chose Republic Electro Paintlok for its popular all-metal outdoor booths.

Electro Paintlok is the zinc-plated steel sheet that is chemically treated to take paints, lacquers, synthetic enamels—and hold them in a tight grip for years, even under hard service and severe exposure.

Furthermore, only minimum maintenance is required. Should the painted surface become scratched, the tight zinc coating protects against underfilm corrosion and

REPUBLIC

World's Widest Range of Standard

REPUBLIC STEEL

REPUBLIC STEEL CORPORATION
3150 East 45th Street • Cleveland 27, Ohio

Please send me more information on:

- ☐ Republic Electro Paintlok
- ☐ Republic Stainless Steel
- ☐ Republic Titanium
- ☐ Republic Mechanical Tubing

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

K-8065A

booths color-bright

provides lasting paint adherence

creeping rust that would eventually cause trouble.

Republic Electro Paintlok is easy to fabricate, too. The well-bonded zinc coating will not fracture during fabricating, will not crack, peel or flake when punched or sheared.

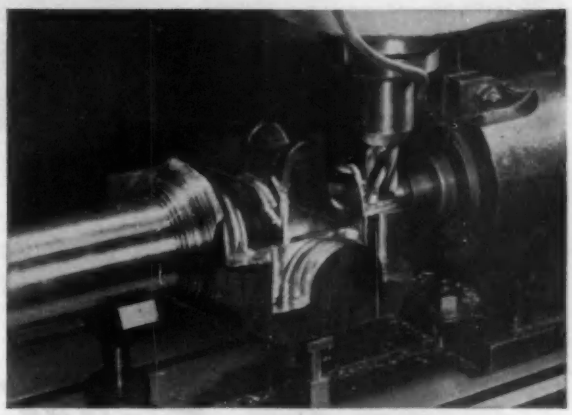
The entire finishing operation is speeded because Electro Paintlok requires no special cleaning. A water-soluble cleaner will quickly remove fingermarks and warehouse dirt. And since surfaces are pre-conditioned, no pre-etching is required.

If you want your painted or enameled steel products to look better longer, get the complete facts on Republic Electro Paintlok. Send coupon for Republic Book 525.

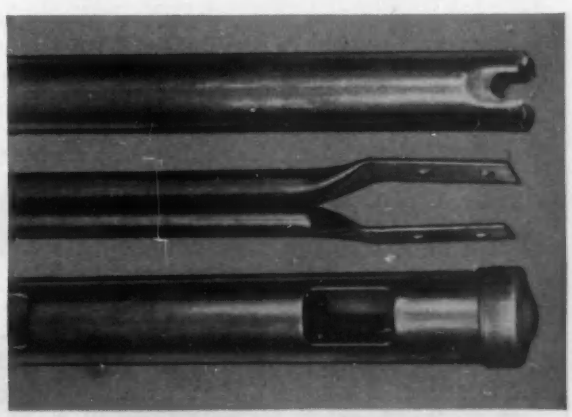
STEEL

Steels and Steel Products

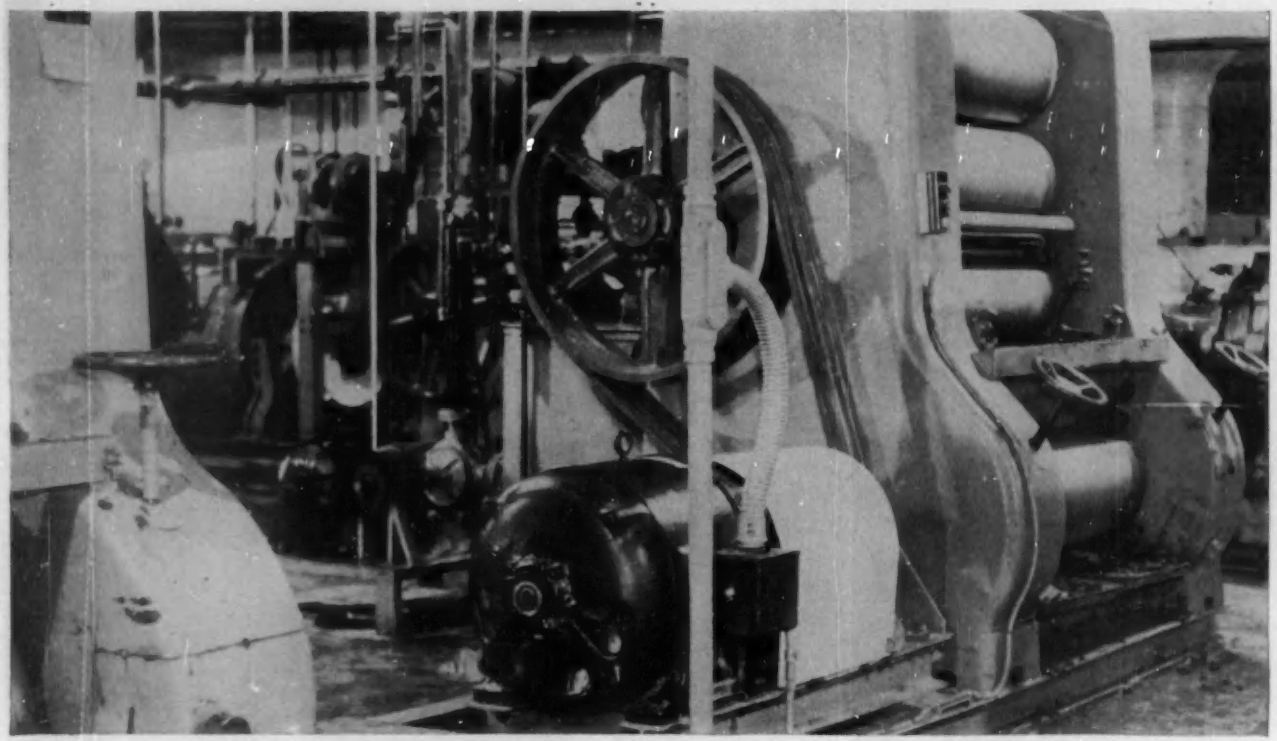
ENDURO STAINLESS STEEL DOES MANY JOBS EFFICIENTLY AND ECONOMICALLY. Here ENDURO, produced at Republic's Alloy Division, is used in a bellows that goes between a jet engine and exhaust tubes because of its heat-resistance and ability to expand and contract uniformly. There are other advantages—such as increased structural strength without added weight. Corrosion-resistance. High physical and chemical properties. Republic metallurgists will help you use ENDURO to best advantage.



TITANIUM PARTS CAN BE MACHINED like parts made from many other metals. This part is being hogged out of a titanium forging at Cleveland Pneumatic Tool Co. It will then be turned, drilled, reamed, ground, tapped, and threaded. Republic metallurgists recommend metals without prejudice. They will tell you whether titanium can be adapted to your product—will help you use it to advantage. Republic produces titanium and titanium alloys in hot and cold rolled bars, sheets, plates and billets at its Alloy Division.



IF YOUR PRODUCT INCLUDES TUBULAR PARTS, you can save an investment in new equipment by letting Republic produce them. Its Steel and Tubes Division has complete facilities for handling all kinds of tough fabricating jobs—like bending, broaching, coiling, configuring, expanding, flattening, grooving, notching, upsetting, tapering—to name just a few. For precision on a production basis—that will lower your fabricating costs—call Republic. Send coupon.

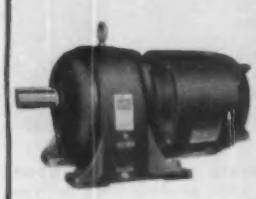


Let each job select

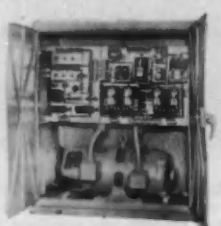
Century MOTORS ARE Performance-Rated®

Why settle for *less* motor than you need? Or why pay for *more* motor than you can use? The most efficient and economical motor is one that is fitted to its application ... A Performance-Rated Century Motor.

Performance-Rating means simply that from



Gearmotors ... ⅛ to 150 H.P. ... parallel and right angle shaft ... "built-in speed to fit your need."

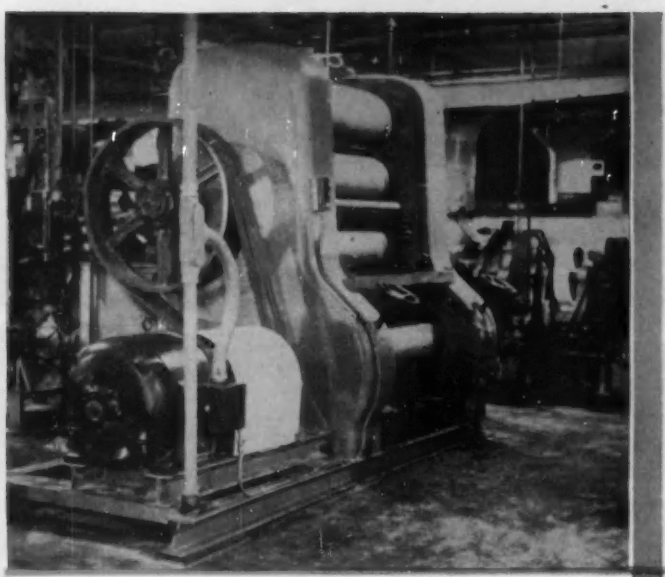


Selective Speed Drive Power Unit ... 1 to 150 H.P. ... a wide range of flexible speed for automatic operation and where fine increments of speed are required.

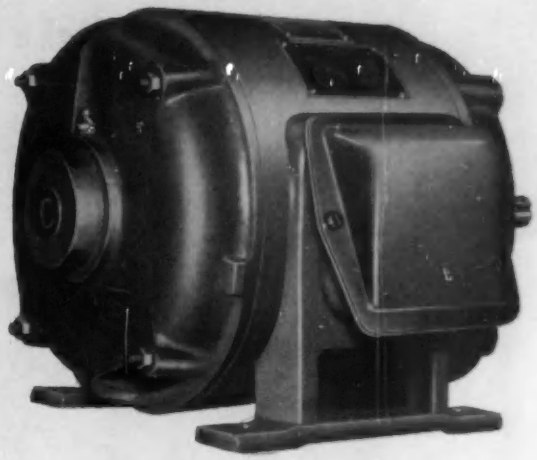
Direct Current Motors ... ½ to 300 H.P. ... a dependable teammate for Selective Speed Drives and where DC is available and its use desirable.

Squirrel Cage, Polyphase Motors ... ⅛ to 400 H.P. ... available in drip proof and dust proof frames, with sleeve or ball bearings, foot or flange mounting (cushion base available through 5 H.P.).

Explosion Proof Motors ... 2 to 50 H.P. ... Underwriters Laboratory listed for safe operation in hazardous atmospheres.



for example: Five-roll refiners are powered by rugged 60 H.P. Century Performance-Rated Motors, chosen to stand up under punishing loads.



Century Motors for Modern Ideas . . . AC or DC . . . Single-phase or Polyphase . . . drip proof, dust proof or explosion proof frames.

its own motor!

TO FIT YOUR SPECIFIC NEEDS

Century's complete line of motors and generators you'll get precisely the right size, speed, frame enclosure and torque characteristics you need. Century application engineers or Authorized Century Distributors are always available to help you fit a Performance-Rated Motor to your job.

FOR THE FULL FACTS ON CENTURY PERFORMANCE-RATING, MAIL THIS COUPON TODAY

To CENTURY ELECTRIC COMPANY
1806 Pine Street, St. Louis 3, Mo.

Please send me information about

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Name.....Title.....

Company.....

Address.....

City.....Zone.....State.....

Slip Ring Motors . . . 1 to 400 H.P. . . . a favorite for applications requiring unusually low starting current. Available in drip proof, splash proof and dust proof frames.

Performance-Rated® Motors
1/8 to 400 H. P.

Offices and Stock Points in Principal Cities

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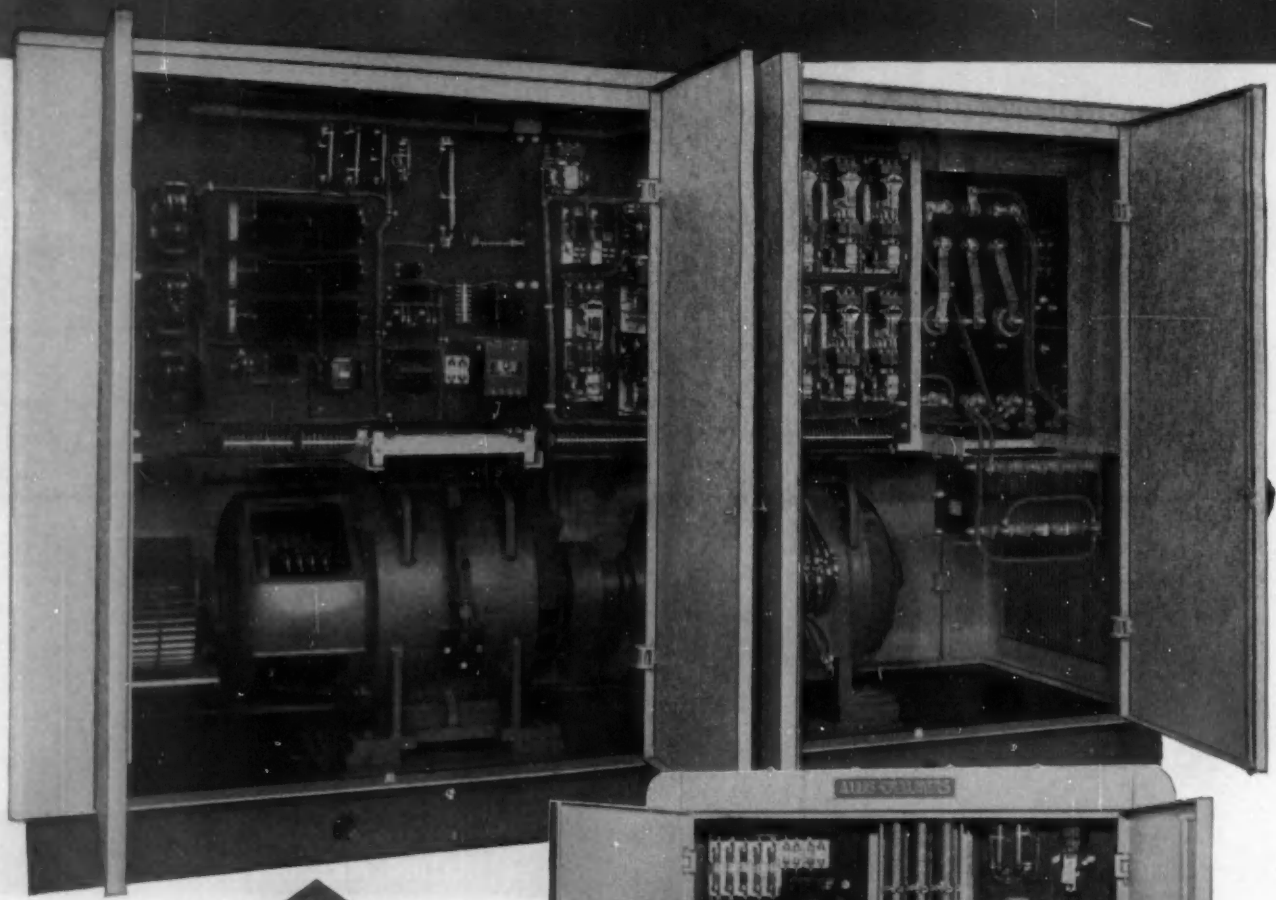
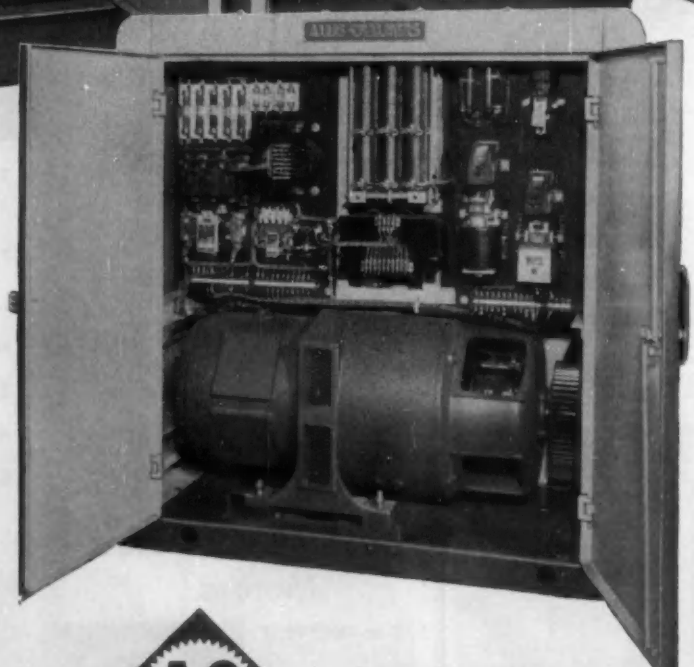
Get the Drive

Tailored to Your Speed



A-C package drive, Size 5, 125 hp. Reversing, dynamic braking (rear view).



Size 2 packaged drive, 25 hp, with electronic speed regulation ¼ of 1% based on top speed, 3550/50 rpm.

A-C ALLIS-CHALMERS

ALLIS-

Control Needs

ALLIS-CHALMERS Package Drive Gives You

- ★ Wide speed range
- ★ Precise speed control
- ★ Operation from one or more points
- ★ Simple installation
- ★ Reduced maintenance

If you need speed control for up to 200 total horsepower plus special performance characteristics such as threading, jogging, dynamic braking, etc., the Allis-Chalmers package drive will provide these functions in one easy-to-specify unit. The package drive itself consists of a motor-generator set and control components mounted in a well-ventilated cabinet. Control stations and dc drive motors may be placed wherever convenient. Installation is simple because the unit is factory-wired and ready to operate. Maintenance is reduced because cabinet keeps equipment clean and out of harm's way. All three of the basic components — m-g set, control and drive motors — are designed to operate as a unit.

Engineering Assistance

Allis-Chalmers application engineers are thoroughly familiar with OEM problems and will be glad to help you at every stage of your operation. For help, call your nearby Allis-Chalmers District Office. For literature, write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B8166. A-4620

Vari-Pitch is an Allis-Chalmers trademark

Other Allis-Chalmers Speed Control Drives

Mechanical

Where a moderate speed range is required and where the machine may be stopped to make required speed changes. Horsepower range — 1½ to 300. Speed adjustment range — 9 to 28 percent. Two *Vari-Pitch* sheaves used together double range of adjustment.

Mechanical

Where speed must be changed while machine is in motion. Particularly good for machines requiring fine adjustment while operating. Double range of adjustment may be obtained by using two *Vari-Pitch* sheaves. Horsepower range—1½ to 600. Speed adjustment range —9 to 28 percent with one *Vari-Pitch* sheave.

Electrical

Where stepped speed control is satisfactory. Available with stepless control in larger sizes by using liquid rheostat. Speed is varied by means of control on secondary windings of motor. Horsepower range — 5 hp and up. Speed adjustment range — 30 to 96 percent of synchronous speed for fan duty.

CHALMERS

Just turn the key..

An R&M Motor

Just turn the key, and a Robbins & Myers custom-designed motor starts the powerful new Mercury 4-cylinder-in-line Mark 55E 40 HP outboard motor, and also the popular 18 HP Mercury Mark 25E model.

This outstanding electrical starter and generator system is the result of extensive research and design work by engineers of the Kiekhaefer Corporation, Fond du Lac, Wisconsin, makers of Mercury outboard motors. Rigid requirements were established on all parts to assure unfailing performance and long service under the conditions in which outboard motors must operate.

One of the most important single factors is the starting motor. It must operate on the 12-volt system, be compact, provide high torque. It must withstand the heavy starting load, rough handling, vibration, exposure to marine conditions. Kiekhaefer engineers handed the problem to Robbins & Myers motor design specialists.

These R & M engineers custom-designed the motor for the job. It develops 8/10 HP at 6000 RPM. It's compact, with an overall length of 6 inches and outside diameter of less than 3½ inches. Commutator, windings, and connections are specially designed for 12-volt service. The motor shaft is specially splined and hardened to resist sudden starting loads. The whole motor is marine-treated with special moisture-proofing to protect it against fresh and salt water, and tropicalized with fungicidal lacquer.

Kiekhaefer engineers, after extensive tests, report that the R & M motor amply meets all the requirements. It has now been used on the Mark 55E and Mark 25E for millions of enjoyable hours. Users are enthusiastic about the smooth, unfailing performance of the "Turn-the-Key" starting system.

Above, cutaway view of the Mercury Mark 25E outboard motor showing location of the R & M starter, and, right, R & M matched motor parts custom-designed especially for this application. Parts are marine-treated and tropicalized to resist salt water and fungus.

starts this new Mercury outboard

How R & M Engineers coordinate motors with your machine design

The Mercury electric motor starter is just one of thousands of applications that require a custom-designed motor. Robbins & Myers engineers specialize in integrating motors with your design problems in building a machine.

We custom-design matched motor parts for portable tools, industrial equipment, appliances, office machines, many other applications. R & M engineers have developed a special electric "slide rule" that cuts motor designing calculation time from months to days. The resultant cost and time savings are passed on to you.

It may be that an R & M standard motor will completely meet your requirements. If so, we can select from our wide choice of types and sizes of complete motors or matched motor parts.

But don't be satisfied with an "off-the-shelf" compromise. Bring your problems to R & M—we'll work with you—in complete confidence—and you can be sure of getting the motors or motor parts that best meet your requirements. Call the nearest Robbins & Myers office—or mail the coupon below for complete information about R & M service.

R&M® ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Fractional HP motors from 1/200 HP • Integral HP motors to 200 HP

R & M Motors and Motor Parts power many types of equipment

Portable power tools . . . vacuum cleaners . . . hedge trimmers and lawn mowers . . . police and air raid sirens . . . food mixers . . . pumps and compressors . . . electric typewriters . . . electronic calculators . . . fans . . . oil burners . . . waxers and polishers.

Mail This Coupon . . . No Obligation

PD

Robbins & Myers, Inc., Springfield, Ohio

Without obligation, please send me bulletins on:

- ☐ Motor parts for portable tools
- ☐ Universal motors
- ☐ Capacitor Motors
- ☐ R & M "All-Weather"* Motors up to 200 HP
- ☐ Please have a motor specialist call on me.

*"All-Weather" is an R & M trademark

*Name*_____

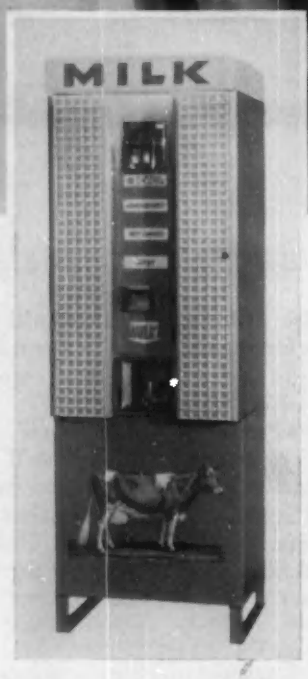
*Firm*_____

*Address*_____

*City*_____ *State*_____

KLIXON *Thermo Snap*® CONTROLS

Help Cup-O-Matic Vending Machines Deliver "Sweet Milk"

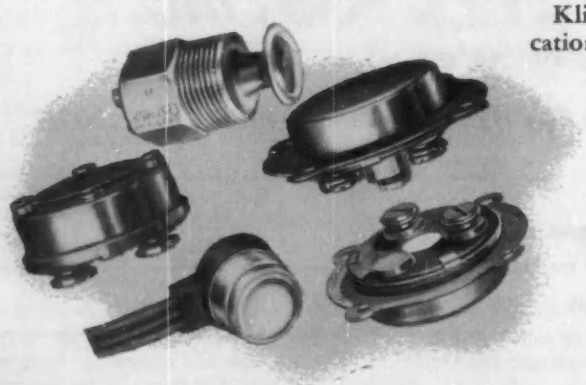


The Cup-O-Matic Vendor, manufactured by Food Engineering Corporation, delivers sweet milk in paper cups in office buildings, schools, factories, etc. Every component of this bulk milk dispenser has been carefully scrutinized and field tested for dependability. That's why Food Engineering Corporation uses Klixon Thermo-Snap Controls.

Mr. J. Walter Hunsinger, Service Manager, has this to say about Klixon Controls:

> "Klixon Controls have proven completely dependable. This dependability is of the utmost importance in milk vending since the Klixon is used as a safety device to shut the machine down in the event that the temperature of the refrigerated area goes above 50 degrees F. This is essential to protect the consumer and is generally required by Health Departments . . . Our use of the Klixon has been based on its reputation as well as our own satisfactory first-hand experiences with it."

Typical Klixon Thermo-Snap Controls that can help you solve your Thermostat Control Problems



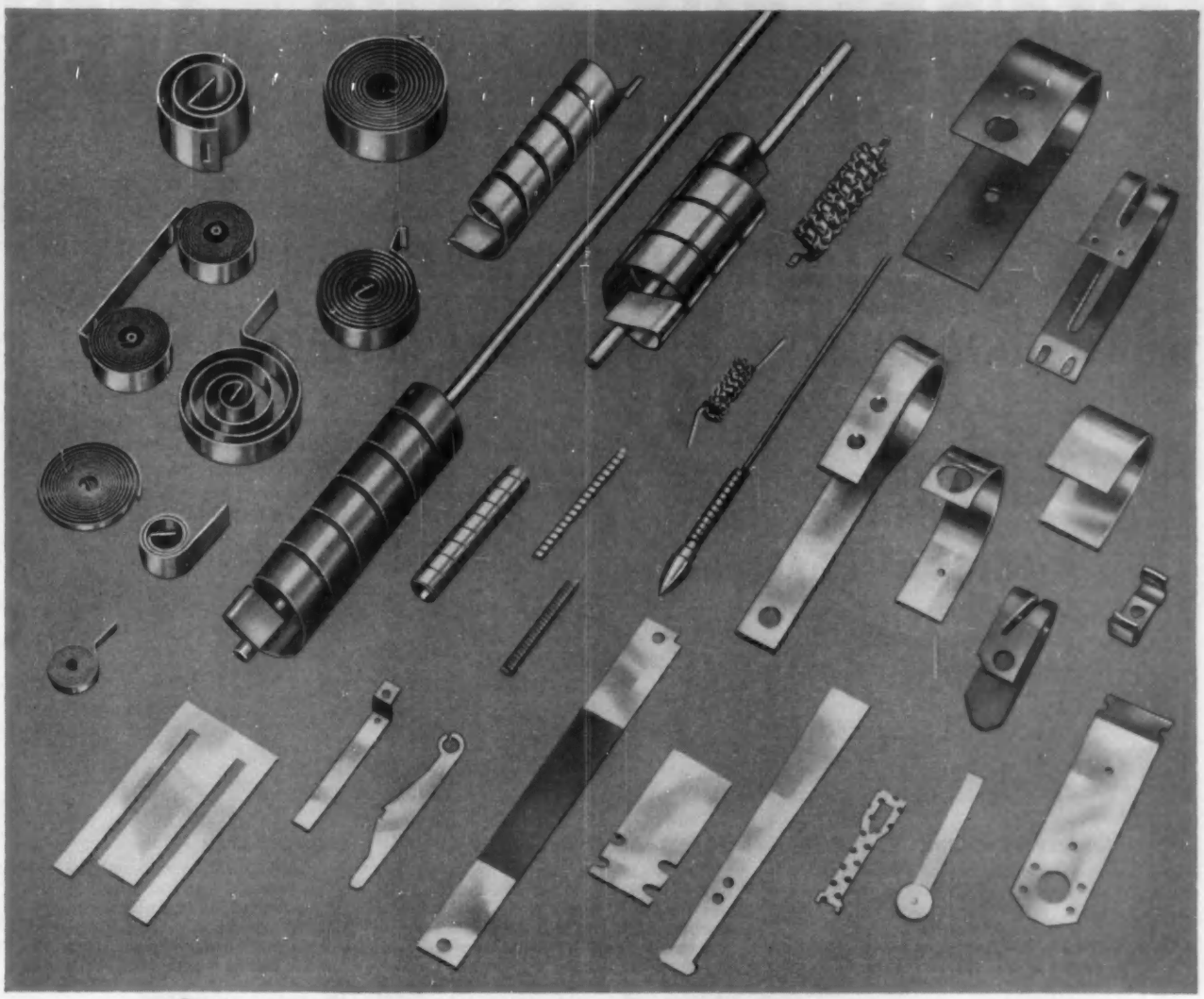
Klixon Thermo-Snap Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges.

Klixon Engineers, specialists in temperature control applications, can help solve your specific problems. Write for their help or further information.

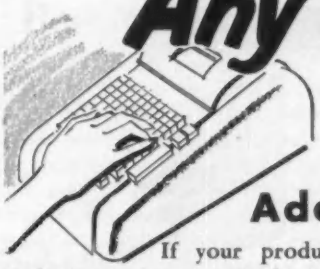
You, too, can benefit by using Klixon Thermo-Snap Temperature Controls.

KLIXON

METALS AND CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
907 FOREST STREET, ATTLEBORO, MASS.



Any way you Figure it...



GENERAL PLATE TRUFLEX®
Thermostat Metals and Assemblies
Add up to Performance and Economy

If your products require temperature control . . . indication or compensation, General Plate TRUFLEX thermostat metals and fabricated elements and assemblies give you reliable, accurate performance and at the same time *cut your costs.*

Here's why — Advanced General Plate production methods coupled with the best equipment available insure positive consistency in thermal and mechanical performance and maintain close dimensional tolerances. Every lot, whether it is 10 pieces or 10,000, is a duplicate of the original, thus eliminating rejects and costly adjustments in assembly.

General Plate TRUFLEX fabricated elements and assemblies ready for installation in your products are engineered and manufactured to your exact specifications. You get accurate and consistent performance, because every order comes to you a faithful duplicate of the original. Costly fabrication problems . . . needless expense for special calibration equipment . . . and time consuming assembly adjustments are eliminated.

General Plate TRUFLEX thermostat metal and assemblies are made to meet your specific requirements for temperature range, electrical resistance, corrosion resistance, etc. If you prefer to make your own elements, General Plate will produce TRUFLEX thermostat metal strip to your material specifications. Write for TRUFLEX thermostat metal catalog and engineering assistance.

You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION

GENERAL PLATE DIVISION

17 Forest St., Attleboro, Massachusetts

CHOOSE THE *RIGHT* LATCH TO DO THE JOB *BEST!*

SOUTHCO DOOR AND PANEL LATCHES

UNIQUE DESIGNS ASSURE LOW INSTALLED COST

FOR ECONOMY...
LONG LIFE...
EXTRA SALES APPEAL...

Here's a variety of rugged, smooth-operating door fasteners designed for countless applications where both economy and smart appearance are important.

Built for long life, SOUTHCO latches hold panels and other closures *pressure tight* to resist vibration and keep out dust . . . despite variations in door and frame thicknesses.

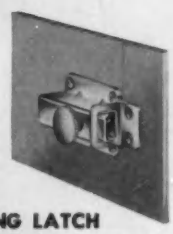
For speedy, uncomplicated installation, using a minimum of parts and requiring fewest possible tools, SOUTHCO latches are unexcelled.

UNIVERSAL CABINET LATCH

For extra fast installation on all sheet metal doors. No welds, bolts, screws, or rivets needed. Adjustable to any grip length. Brightly finished knob and plated washer make this an appealing fastener for smart appearing cabinets.

ADJUSTABLE PAWL FASTENER

Automatically adjusts, by a turn of the knob, to various door or frame thicknesses. Preassembled for fastest installation. Knobs are brightly plated to improve appearance of equipment. Choice of three body sizes. Choice of pawls offers wide variety of adjustable grip lengths.



SLIDING LATCH

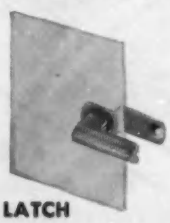
Seals door and frame together under pressure with just a turn of the knob. Permits easy alignment, smooth operation. No part of latch is inside door. Appearance is suitable for the best finished products. Also an inside model with only locking screw visible.

Which of these SOUTHCO latches can serve you best? Write us for full information. Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

©1955

ARROWHEAD PANEL LATCH

Ideal for slide-out drawers, removable or hinged panels. Locks or opens quickly with a quarter turn. Holds doors shut under spring tension. Uses minimum inside space.



DOOR LATCH

Meets the need for a low-budget fastener for control boxes, machinery, hot water heaters, and other light gauge sheet metal closures for home or industrial use. Just two simple parts, installed in seconds *with only a pair of pliers*. No striker plate needed. Also available in a screwdriver operated model.

SOUTHCO®
FASTENERS

PAWL • SCREW AND SPRING • DRIVE RIVETS • ANCHOR NUTS • ENGINEERED SPECIALTIES

OFFICES IN PRINCIPAL CITIES

WHEREVER TWO OR MORE PARTS ARE FASTENED TOGETHER, STANDARD AND SPECIAL DESIGNS FOR IMPROVED PERFORMANCE AND LOWER PRODUCTION COSTS

DU PONT
REG. U.S. PAT. OFF.
Better Things for Better Living . . . through Chemistry

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NO. 5 — 1955

Clutch Lever Assembly Bushing of TEFLON® Successfully Completes 300,000 Cycle Test

The 1955 Mercury clutch lever assembly uses a 0.014″-thick, wrap-around bushing of Du Pont "Teflon" tetrafluoroethylene resin. The bushing of "Teflon" outperformed bronze in this application and, in addition, reduced unit cost.

Lincoln-Mercury design engineers reduce unit cost with bushing of "Teflon"

THE use of a clutch lever assembly bushing of Du Pont "Teflon" tetrafluoroethylene resin has solved two problems for Lincoln-Mercury designers, and provided a unit cost reduction in addition.

Original thinking was to use a bronze bushing, and lubricate this through a grease fitting. However, the bushing was located near the exhaust pipe; heat might affect the lubricant. The second problem was that all possible locations for the grease fitting were so difficult to reach that lubrication would be almost impossible.

Lincoln-Mercury engineers tested a wrap-around bushing of Du Pont "Teflon" (see cut). The 0.014″-thick bushing satisfactorily completed a 300,000 cycle test—the equivalent of ten years' operation. During this test, the bushings of "Teflon" tetrafluoroethylene resin were subjected to water, dust and oil.

Better Performance at Less Cost

The experiment was judged a complete success. Not only does the bushing of "Teflon" resist wear better than the bronze bearing in this application; it also cuts costs by eliminating the grease fitting, its drilled and tapped hole and another drilled hole in the clutch lever shaft.

Use the coupon on the other side of this page for more information about this versatile Du Pont engineering material—"Teflon" tetrafluoroethylene resin.

OVER

How Parts Engineered of TEFLON® Beat a Heat, Vapor and Taste Problem

THE lead-through insulators and glass gauge gaskets for this Best Automatic Coffee Maker are constantly immersed in near-boiling water. Of all the insulating materials tested by the manufacturer, only DuPont "Teflon" provided the necessary dielectric properties—and yet did not swell, disintegrate or give a foreign taste to the coffee.

"Teflon" tetrafluoroethylene resin has a working temperature range of −450° F. to 500° F. and zero moisture absorption. It is chemically inert, has a low coefficient of friction, self-lubricating properties and non-stick characteristics.

For complete information on this unique engineering material, use the coupon on the other side of this page.

Best Automatic Coffee Maker with insert showing lead-through insulators and glass gauge gaskets of "Teflon". Du Pont "Teflon" is used for its excellent resistance to heat and moisture, plus its dielectric properties. (Coffee Maker manufactured by Best Products Company, Chicago, Illinois.)

DU PONT
REG. U.S. PAT. OFF.

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NO. 5 — 1955

Molded part of LUCITE® keeps out dirt, lint

WINDING ROLLS, used in the textile industry, now use end caps of Du Pont "Lucite" acrylic resin to prevent dirt and lint from accumulating and contaminating yarn.

Why is "Lucite" used? The manufacturer says these caps are produced for him in an economical 70-second cycle. The center hole is reamed to close tolerance and the angular hole is tapped—both easy operations. The end result is an attractive looking part that resists breakage and discoloration and helps make the winding operation on textile machinery more economical.

Property and application data on "Lucite" is available on request. Use the coupon below for complete information.

Winding machines are protected from accumulations of dirt and lint by these economically molded end caps of Du Pont "Lucite" acrylic resin. (Caps manufactured for the Universal Winding Company, Providence, Rhode Island, by Cowan Boyden Corporation, Providence, Rhode Island.)

Investigate Du Pont engineering materials in your product development programs

ONE of the family of these versatile engineering materials is often a key factor in product improvement or new design.

The wide range of properties available with "Alathon"* polyethylene resin, "Lucite"* acrylic resin, "Teflon"* tetrafluoroethylene resin, and "Zytel"* nylon resin are helping solve industrial design problems.

NEED MORE INFORMATION?

CLIP THE COUPON for additional data on the properties and applications of these Du Pont engineering materials.

"Zytel"* Nylon Resin Simplifies Design, Resists Wear, Reduces Maintenance

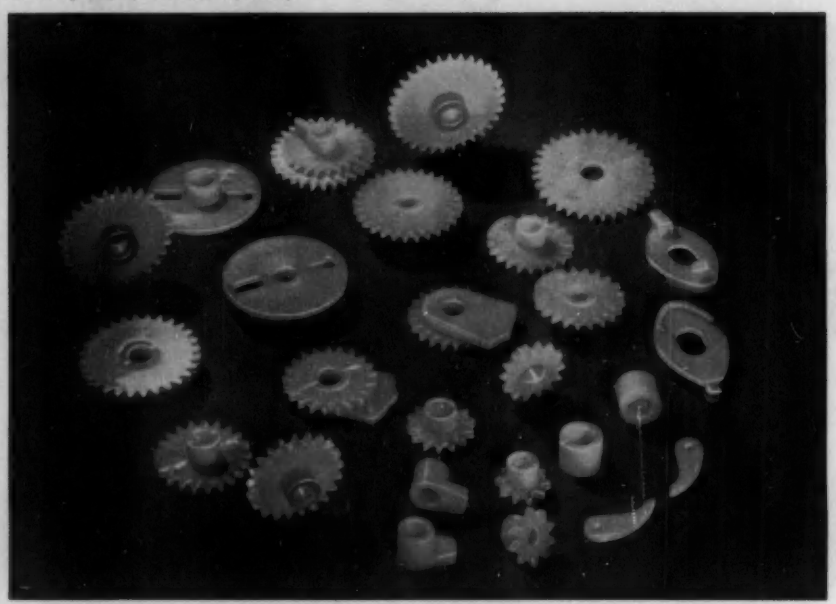
Separator blocks, molded of "Zytel" nylon resin, are toothed blocks which receive separate bars in new Autographic Register. Other parts of "Zytel" are shown below.

Gears, bushings, and sliding cams—molded entirely of Du Pont "Zytel" nylon resin. "Zytel" is lightweight, wear-resistant; can be injection-molded into complex shapes efficiently and economically. (Autographic Register manufactured by Krauth and Benninghofen Company, Hamilton, Ohio; parts of "Zytel" molded by Nylon Molded Products Corporation, Garrettsville, Ohio.)

ALL the gears, bushings and other parts in this Autographic Register used to be made of metal. Now they're injection-molded Du Pont "Zytel" nylon resin—a total of 28 parts altogether. The designer specified a change to "Zytel" for the following reasons:

Parts of "Zytel" nylon resin are tough and durable—even in thin sections. "Zytel" also has excellent abrasion resistance. This engineering material needs little or no lubrication, simplifying maintenance; and yet in many instances, parts of "Zytel" have a longer service life than conventional materials. Operation is quiet, mechanical vibration is absorbed by "Zytel".

Another important property of "Zytel" nylon resin is lightness. When "Zytel" replaces other materials, there's often a significant saving in weight. Through the injection-molding process, designers can often reduce the number of parts—making one molded complex piece do where normally an assembly of two or more pieces made from conventional materials are needed. This injection-molding process can not only reduce assembly time but also speed production as well.



Complete test and property data on this versatile Du Pont engineering material—"Zytel" nylon resin—is available on request. To obtain this information, simply fill out the coupon on this page.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 107, Du Pont Building, Wilmington 98, Delaware.
In Canada: Du Pont Company of Canada, Ltd., P. O. Box 660, Montreal, Quebec.

Please send me more information on the Du Pont engineering materials checked: ☐ *"Zytel"*; ☐ *"Alathon"*; ☐ *"Teflon"*; ☐ *"Lucite". I am interested in evaluating these materials for:*

NAME _____ POSITION _____

COMPANY _____

STREET _____

CITY _____ STATE _____

TYPE OF BUSINESS _____

*"Alathon", "Lucite", "Teflon", and "Zytel" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)

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Waterbury 20, Conn. Dept. PE-755

Gentlemen:

_____ *Please send me more information on your 16 mm, full-color film, "In the Chips."*

_____ *I would like to arrange for a showing on or about* _____

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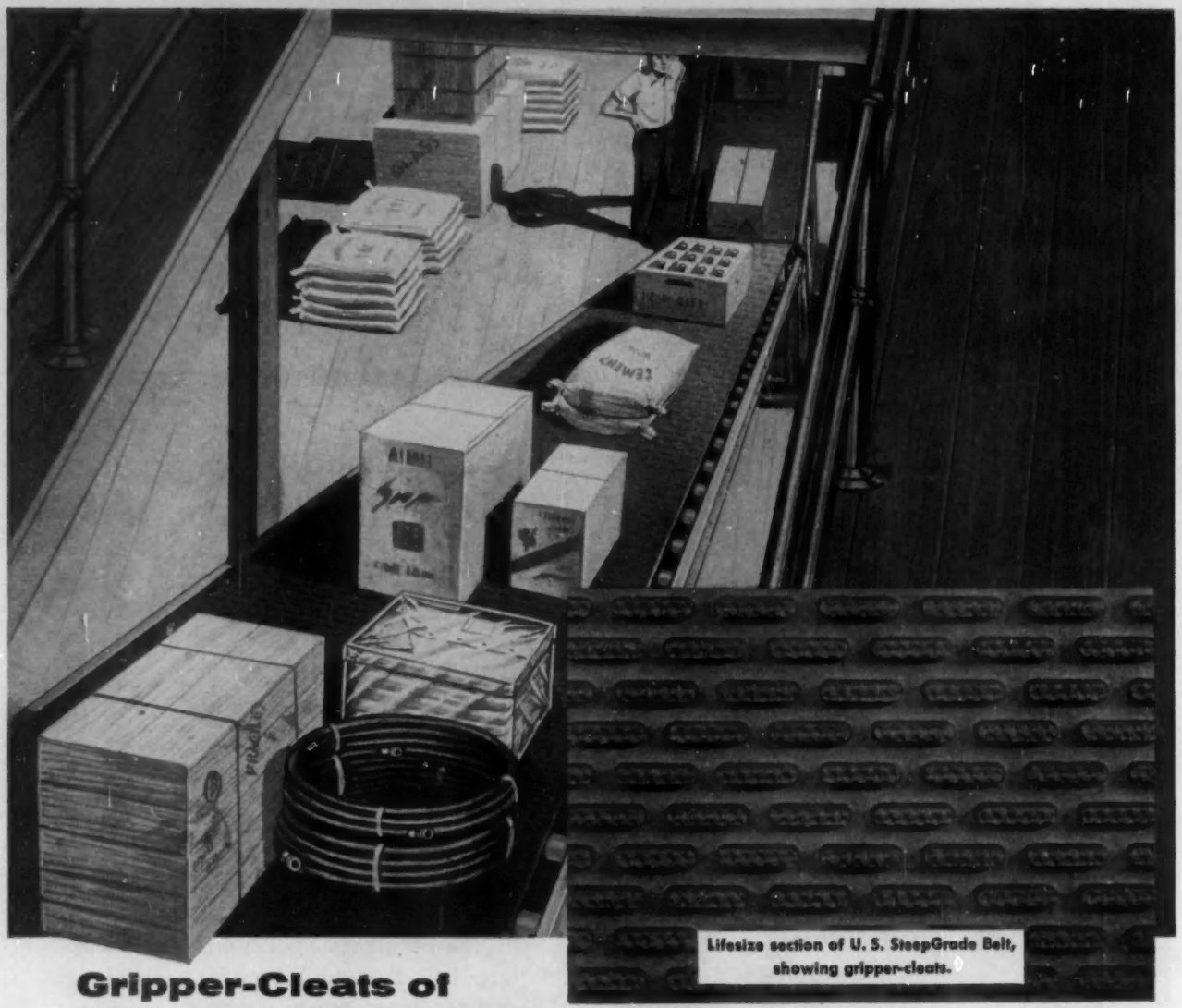
POSITION _____

FIRM _____

ADDRESS _____

CITY _____ STATE _____



Lifesize section of U. S. SteepGrade Belt, showing gripper-cleats.

Gripper-Cleats of U. S. STEEPGRADE Provide Non-Slip Package Control on Steep Inclines and Declines

The new, *exclusive* gripper-cleats of the U. S. SteepGrade Belt give positive non-slip control of many materials on ascents or descents as steep as 45 degrees. This feature also saves floor area and belt footage, because the steeper the incline the less floor space occupied. The U. S. SteepGrade Belt is perfect for small buildings.

Note the gripper-cleats in the close-up photo of the belt section. These cleats are *not* attached or cut in; they are *molded*—a true and integral part of the belt. That's why they resist being torn off by heavy cases. The special surface design allows the belt to *clean* itself as it flexes over the pulleys.

This remarkable new belt is obtainable at any of the 27 "U. S." District Sales Offices or by writing address below.

"U. S." Research perfects it . . . "U. S." Production builds it . . . U. S. Industry depends on it.

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This Cleveland, now driving an octagonal thickener in a New England paper mill, is a real "old timer". Originally installed nearly 40 years ago in a different application, it is still on the job after so many years of constant service.

Where you can use a Worm Gear Drive to best advantage

WHEREVER power transmission calls for a compact, safe, space-saving speed reducer, a Cleveland worm gear drive is your first choice.

The right angle construction of a worm gear saves space. High shock load resistance and efficient performance are inherent. Parts are reduced to a minimum. There's smooth, uninterrupted torque flow and quiet running. Correct gear alignment is maintained. Gearing is enclosed in an oil bath, assuring positive lubrication, minimum maintenance and safety for operators. The case hardened steel worm and nickel-bronze gear actually improve with use, adding to long life. And, with Clevelands, you get the extra advantages of the 42 years' experience of specialists in building worm gears.

In thousands of cases, Cleveland speed reducers have operated for the life of the driven machine through years of severe service. Get the complete Cleveland story, before you install a speed reducer; see how much Clevelands can do for you. Write for helpful technical advice and ask for Catalog 400. The Cleveland Worm and Gear Company, 3279 East 80th Street, Cleveland 4, Ohio.

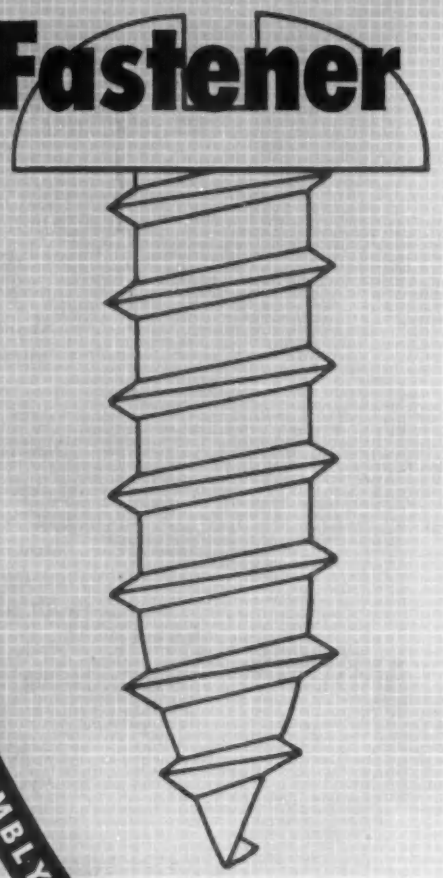
Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers

ASSEMBLY COSTS GO DOWN

Millions in Savings have made it

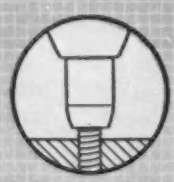
The Fastener



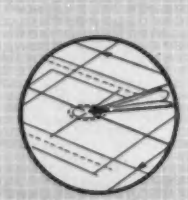
Save cost of tapping and tap equipment

Save cost of "two-side" fastening — nut-running, riveting, etc.

Save cost of inserts for machine screws in plastics



Permit extra speed of power and automatic driving



Permit simpler design — fewer fastenings

ASSEMBLY COSTS STAY DOWN

PLAN FOR LOWER COST

from savings like these and from many more assembly advantages of Self-tapping Screws . . . then

PURCHASE TO *KEEP* COST DOWN

Insist on *P-K quality* to guard against screw failure and loss of most planned savings. Screw faults are hard to detect, but cost sheets and customer complaints soon show their effects — job slowdown, parts damage, high reclamation costs, loosening under vibration, hidden weakness.

P-K QUALITY STANDARDS PROTECT YOU

against "softies," and "cripples," — any defective screws. That's why *all* P-K Screws you get can be *Guaranteed First Quality.*

IN STOCK
See your P-K DISTRIBUTOR

PARKER-KALON®

Remember

. . . for screws that START RIGHT . .

IDEA of the CENTURY

In the past hundred years, the one revolutionary idea in threaded fasteners was pioneered by Parker-Kalon . . . hardened Self-tapping Screws.

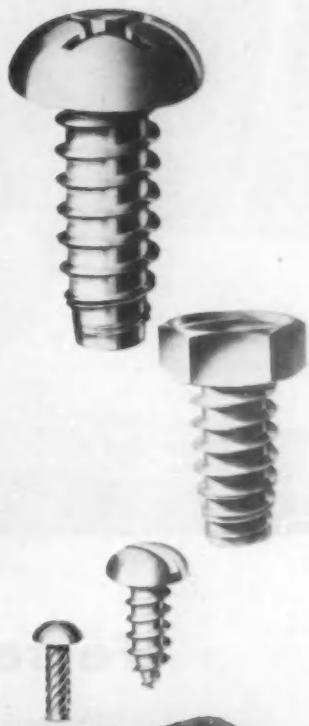
They offered simplicity, speed, and security for fastenings to metals, plastics, laminates, — savings impossible with conventional methods. They inspired the modern assembly techniques essential to mass production. Their contribution to cost reduction mounts by millions every year.

For almost any assembly, there's a big potential saving with Self-tapping Screws. But the promise can fade in production if screw failure snarls up the line. That's why quality standards for P-K Self-tapping Screws were set so high to begin with, and are still harder to match today.

Only Parker-Kalon can offer P-K quality, the indispensable extra, along with the proved advantages of Self-tapping Screws.

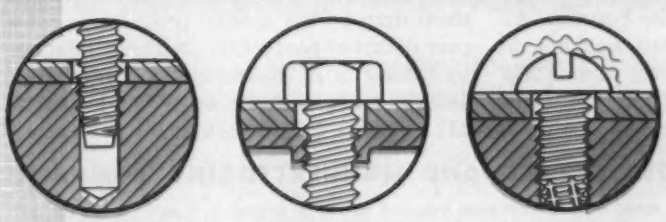
Only Parker-Kalon can offer P-K experience — covering many more years and millions more applications than any comparable record.

Plan your assemblies for lowest cost . . . a P-K Assembly Engineer will help you. Then make sure *planned* savings keep on *paying off* . . . when you purchase, order "P-K". Parker-Kalon Division, General American Transportation Corporation, 200 Varick St., New York 14.

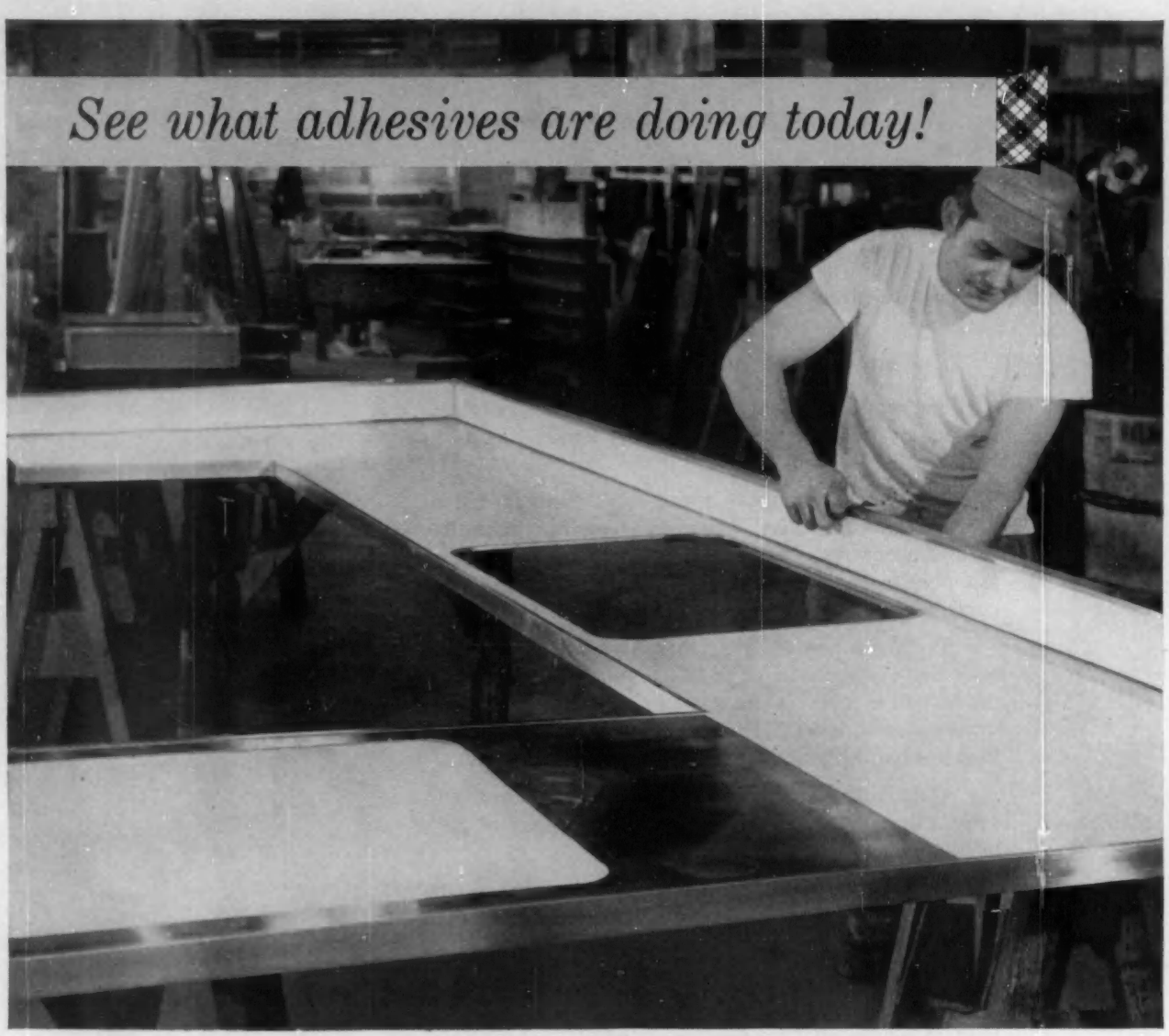


The First originated by P-K . . . and *first* today . . . the leading choice for fastening economy

SELF-TAPPING SCREWS



. . DRIVE RIGHT . . . SEAT RIGHT . . . STAY TIGHT . . . **P-K** means **OK**



Fastening Formica® to stay

3M ADHESIVES

What's going *under* the counter in today's modern kitchens? In many progressive kitchen-equipment companies, it's the 3M adhesives EC-1357 and 1368. These "quick grabbing" adhesives have what it takes to bond satiny smooth surfaces like Formica and steel together—and bond them to stay.

Not long ago, however, this particular manufacturer used *wood* bases for all counter tops of high-pressure laminates like Formica. All the adhesives tried on steel just wouldn't do the job satisfactorily. But along came a 3M Field Engineer to point out the talents of EC-1357. It was tried . . . proved . . . used. Now this manufacturer can skip the wood bases and make cabinets *all steel*. His gain? Important production economies in both material and handling . . . while offering a better, longer-lasting cabinet in the bargain.

See what adhesives can do for you . . .

This is just one example of the work being done by over 1000 specialized 3M adhesives, coatings and sealers in industry today. Among them may be the specific products to solve *your* design or production problems. Find out by talking to an expert; call in your nearest 3M Field Engineer. Or write 3M, Dept. 47, 417 Piquette, Detroit 2, Mich.

ADHESIVES AND COATINGS DIVISION **MINNESOTA MINING AND MANUFACTURING COMPANY**

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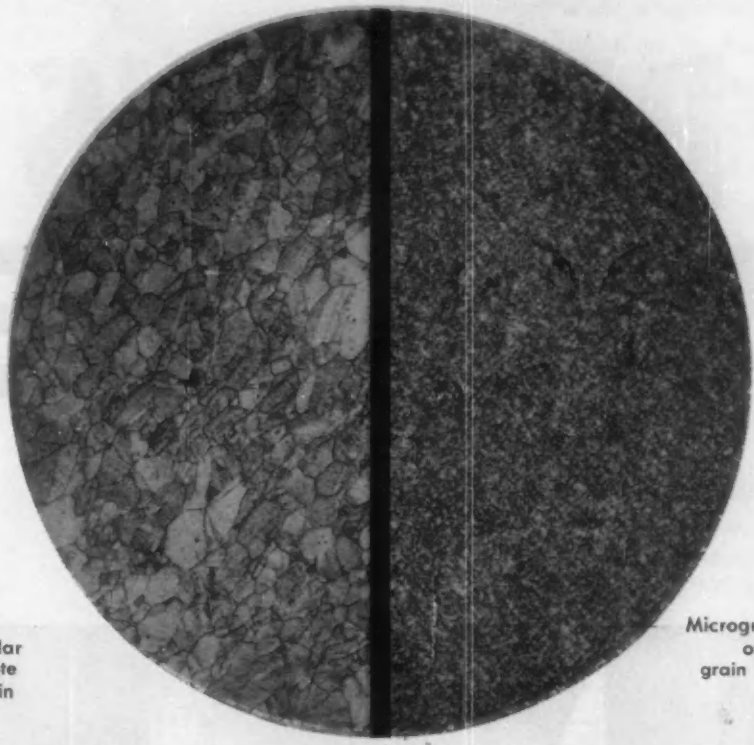
Get longer life in formed parts AT NO EXTRA COST

USE THE NEW FINE GRAIN PHOSPHOR BRONZE WITH 30% GREATER ENDURANCE LIMIT



Micrograph (75x magnification) of regular phosphor bronze. Note relatively coarse grain structure.

Micrograph (75x magnification) of Duraflex. Its fine grain structure is the secret of its superiority.

DURAFLEX*

BY ANACONDA

DURAFLEX is a new, fine-grain phosphor bronze developed and sold only by Anaconda. Comparative fatigue tests show that the endurance limit of DURAFLEX is approximately 30% higher than for regular phosphor bronzes. In surface appearance, surface smoothness and hardness, it is superior to other phosphor bronzes. It is unsurpassed in corrosion resistance by any other phosphor bronze. Further, its formability is increased with no sacrifice in yield strength. DURAFLEX is a *premium* phosphor bronze in every way except cost; there's *no increase in price.*

If you're now using a hard-temper phosphor bronze, chances are that you can do the same forming in extra-hard temper DURAFLEX.

If you're looking for longer life in the parts you form, we'll be glad to send you a free sample of DURAFLEX. Try it, test it, and you will agree that it is superior.

5681

*Trade Mark

SEE FOR YOURSELF—

AN

ANACONDA®

PRODUCT

MADE BY THE AMERICAN BRASS COMPANY

FREE SAMPLE

The American Brass Company, Waterbury 20, Conn.

(In Canada: Anaconda American Brass Ltd., New Toronto, Ontario)

Yes, we'd like to try DURAFLEX. Please send us a free sample of

sheet in_____**temper,**_____**thick,**

wire in_____**temper,**_____**diameter.**

☐ **We'd like to talk to one of your representatives about DURAFLEX.**

NAME.....

COMPANY.....

STREET.....

CITY.....**STATE**.....

SHEET . . . up to 0.062" thick
WIRE . . . up to 3/16" diameter (approx.)

FULTON SYLPHON

BELLOWS HEADQUARTERS,

Seamless Metal Bellows

The Sylphon Bellows was originated by Fulton Sylphon over 50 years ago. Its unique one-piece expansible and collapsible design is used widely for diaphragm effects, flexible connections and expansion chambers.

All Types, Sizes and Metals

Fulton Sylphon Bellows are all designed to specific customer requirements. They are furnished in a limitless number of sizes, a complete range of types and metals and with many different reaction characteristics.

On-Call Engineering Service

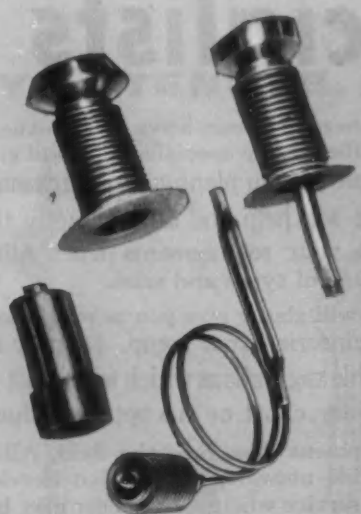
Fulton Sylphon Bellows Engineers are strategically located in all industrial areas of the country. This "near-by" service is on-call to help you determine the right bellows metal, correct bellows charge and most economical design for your specific application.

U.S.A.

For the conversion of pressure effects into controlled movement, the operation of valves and switches in response to temperature change, the absorption of thermal or pressure expansion or the absorption of vibration—a seamless metal bellows may be your best design solution.

The best way to find out, is to consult a Fulton Sylphon engineer. He'll focus more than 50 years experience in bellows engineering on your problem.

Robertshaw-Fulton
CONTROLS COMPANY
FULTON SYLPHON DIVISION



Assemblies and Complete Devices

By purchasing complete bellows assemblies and devices rather than buying bellows units, many manufacturers achieve significant production economies. Fulton Sylphon is singularly equipped to design and produce complete assemblies at low cost.

On-Time Delivery • No Delays

Fulton Sylphon's mass production facilities are geared to good service. Exceptional quality control techniques often eliminate any need for customer's in-coming inspection. Customer service and shipping follow-through assure on-time delivery without costly delays.

BASIC BELLOWS ENGINEERING
and ways Fulton Sylphon can serve you are described in this 32 page Bellows Catalog. It makes profitable reading . . . use the handy coupon to get your free copy.

FULTON SYLPHON DIVISION
Knoxville 1, Tennessee

☐ Please have a Bellows Engineer call me for an appointment.

☐ Send me Bellows Catalog No. NP-1400.

Name_____

Company_____

Address_____

City_____ State_____

Your Design Problems

PROBLEM: Lay Out Piping Most Economically

PROBLEM: Adapt One Pump to All Units

PROBLEM: Stocking Too Many Models

PROBLEM: Mounting Method Restrictions

SOLVED

by ALLIS-CHALMERS Pump Specialists

Your Allis-Chalmers representative is an experienced, highly qualified pump specialist who will give you full cooperation — from planning to purchasing to production. He will help you select exactly the right pump to fit your requirements from Allis-Chalmers wide range of types and sizes.

The A-C expert will gladly give you as much help as you need in engineering your setup. He may be able to make valuable suggestions which will result in savings of time, money, effort, or in a better product.

Once your equipment goes into the field, Allis-Chalmers nationwide network of Certified Service Shops assures fast service wherever the user may be, relieving you of part of your service problem.

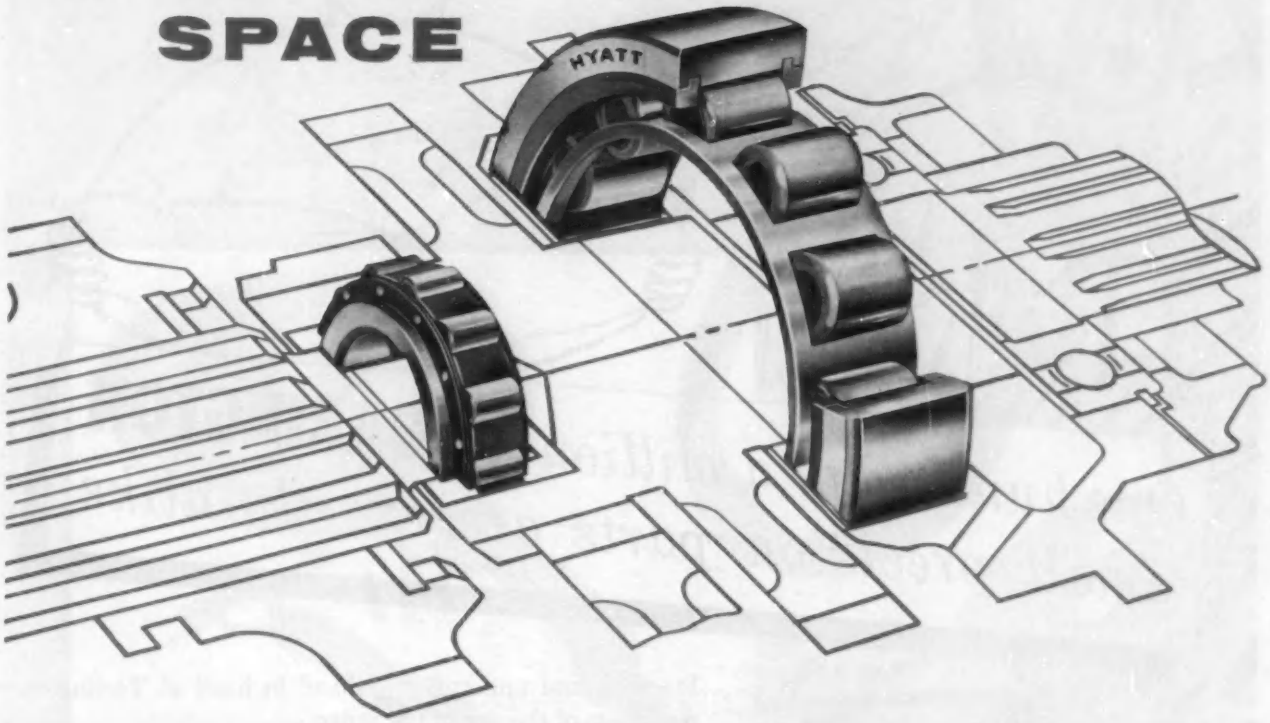
Allis-Chalmers OEM pumps are available from strategic stocking points all over the country. Contact your A-C District Office for details on how to expedite pump selection and ordering, or write Allis-Chalmers, Milwaukee 1, Wis., for more information.

A-4753

ALLIS-CHALMERS

How Hy-Loads can help you

...SAVE SPACE



HY POTENUSE, the sage of the slide rule, SAYS:

your COMPLETE LINE of cylindrical roller bearings

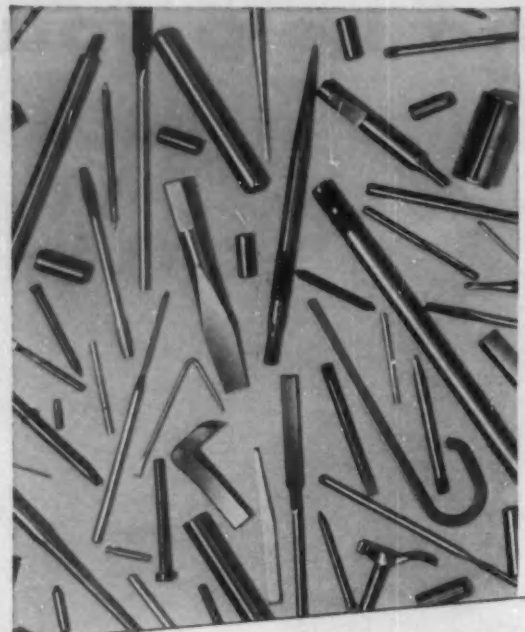
Here's a tractor transmission where the designer's done a mighty fine job of cramming the whole works into a housing with dimensions tighter than McTavish's purse strings!

See how he did it? He used a HYATT BU-type Cylindrical Roller Bearing at the pilot position with the *outer race omitted.* Then on the input shaft he used a HYATT TS-type bearing with the *inner race omitted.* Gear-box size is held to a minimum with maximum bearing capacity! Hyatt makes 4 types of Hy-Loads with separable inner races and 2 types with separable outer races. And brother, they sure come in handy when you're cramped for space! If you haven't a HYATT General Catalog No. 150 handy, better send for yours right now. It'll help you find the answer to lots of pesky problems. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT

ROLLER BEARINGS

STRAIGHT ◯ BARREL ◯ TAPER ◯



One hundred or a million . . . **TORRINGTON** *small precision parts are exactly alike*

Precision and uniformity go hand in hand at Torrington—regardless of the size of the order.

Automatic equipment of special design, and the know-how gained in almost 90 years of precision metalworking enable us to produce your small precision parts to the highest standards of uniformity.

Let us produce a trial order for you. Send your blueprint or a sample part for our prompt quotation. Ask for our Condensed Catalog. It shows many of the parts we can make *faster, better and for less* than you can yourself.

THE TORRINGTON COMPANY
Specialties Division
230 Field Street, Torrington, Conn.

TORRINGTON *SPECIAL* **METAL PARTS**

Makers of Torrington Needle Bearings

Another new product... made better ... with G-E silicone rubber parts

Fabricated G-E silicone rubber gaskets for this automatic skillet give lasting service despite high temperatures!

DEVELOPING A NEW PRODUCT? Perhaps G-E fabricated silicone rubber parts can help you! For example, this G-E automatic skillet called for gaskets that would give positive, *lasting* action *despite high temperatures.* General Electric Plastics Department engineers, after careful evaluation of all possible materials, solved the problem by fabricating seals of a specially formulated G-E silicone rubber. **RESULT?** Long-lasting seals that won't char or crack under severe thermal and electrical stresses . . . that *help insure buyer satisfaction* for the manufacturer!

Perhaps you can make your product better—with fabricated G-E silicone rubber parts! Let G-E plastics engineers show you how it helps improve designs, cut costs, add sales appeal to products!

Write: Plastics Department, General Electric Company, Pittsfield, Mass.
Plants at Decatur, Illinois—Taunton, Massachusetts S50-3B

Progress Is Our Most Important Product

GENERAL ELECTRIC

Ready for the Rope?

Don't give up! Here's all you need in order to get the whole story of how these MPB's* are solving problems in the design of precision instruments

BALL BEARINGS ACTUAL SIZE

CUT THE CALAMITY AND CUT OUT THE COUPON

Miniature Precision Bearings, Inc., 4 Precision Park, Keene, N. H.
YES! Please send me the reprint of the article, MINIATURE BALL BEARINGS FOR PRECISION INSTRUMENTS

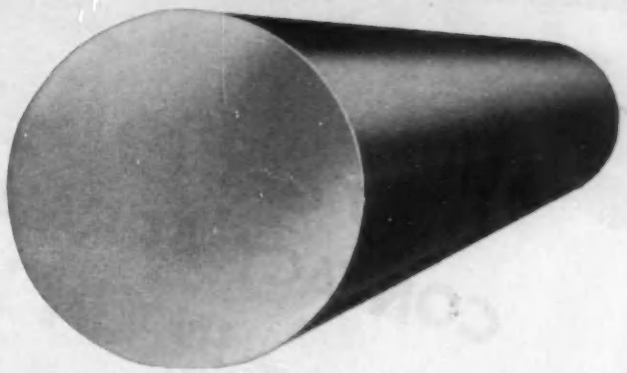
name title company

street city zone state

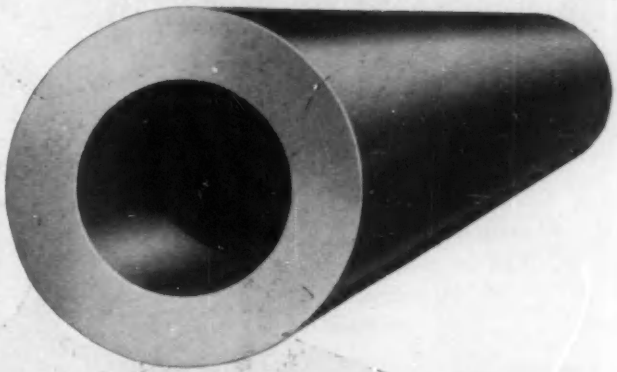
*MINIATURE PRECISION BEARINGS, INC., KEENE, N. H.

When you make hollow parts . . .

Why use bar stock?



start with seamless tubing



Save steel, machining time!

WHY bore out bar stock to make hollow parts when Timken® seamless steel tubing lets you start production with the center hole already there? You don't waste steel and you save machining costs, too. Finish boring is often your first production step. Screw machine stations can be released for other jobs. So you add machining capacity without adding machines. And you save money because you pay only for the steel you use.

Our engineers will save you even more money, too, by studying your problem and recommending the most economical tube size for your hollow parts jobs, guaranteed to clean up to your finished dimensions.

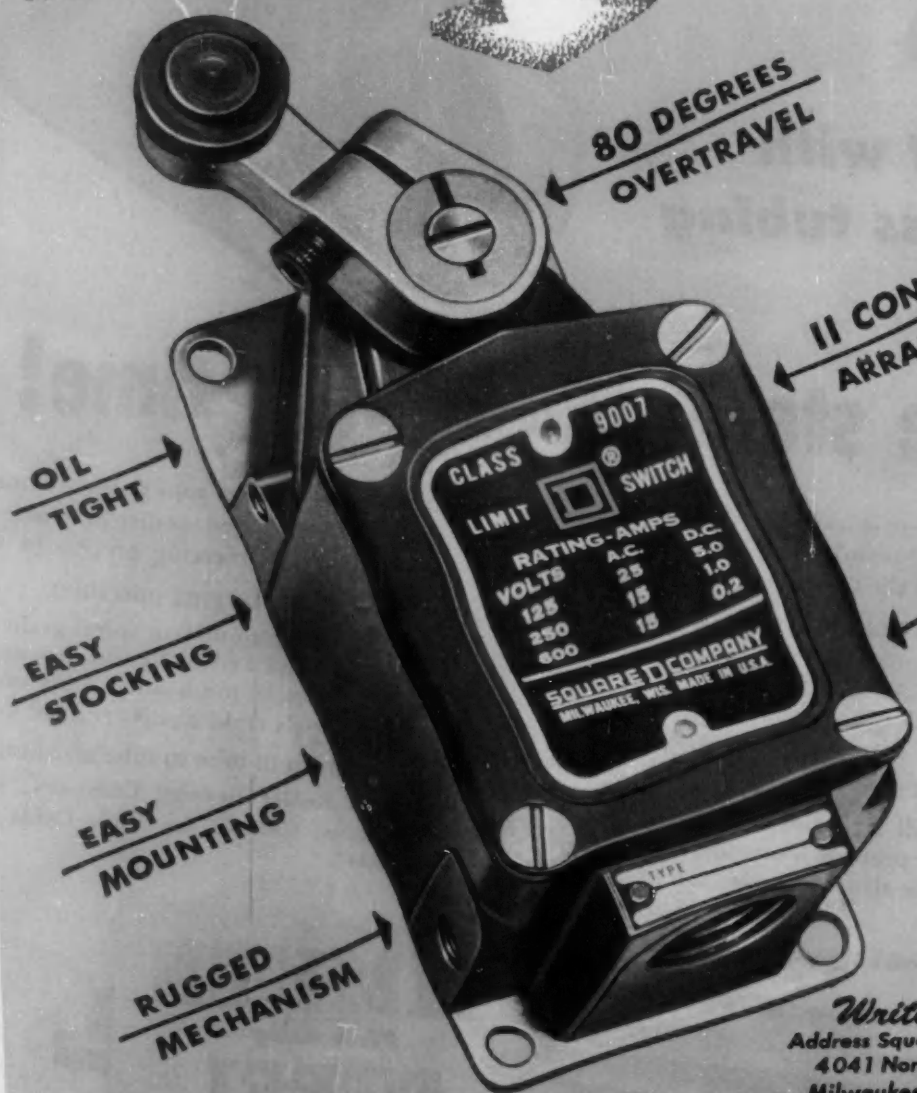
You also get fine forged quality in Timken seamless steel tubing. The piercing process by which it is made is basically a forging operation.

It gives the tubing a uniform spiral grain flow for greater strength, and a refined grain structure which brings out the best in the quality of the metal. The Timken Company's rigid quality control keeps this quality uniform from tube to tube and heat to heat. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD — THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

YOU GET eleven CONTACT ARRANGEMENTS IN one



80 DEGREES OVERTRAVEL

11 CONTACT ARRANGEMENTS

SIMPLE ADJUSTMENT

OIL TIGHT

EASY STOCKING

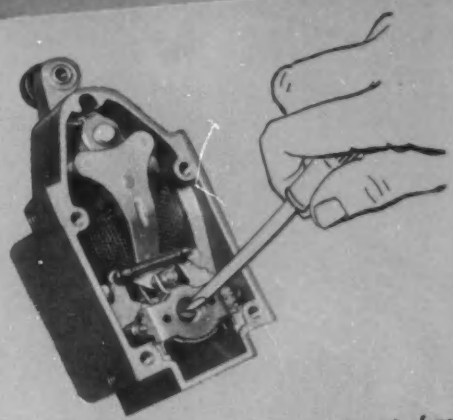
EASY MOUNTING

RUGGED MECHANISM

Write for Bulletin SM-239
Address Square D Company,
4041 North Richards Street,
Milwaukee 12, Wisconsin

SQUARE D COMPANY

WITH THIS NEW MACHINE TOOL
LIMIT SWITCH!

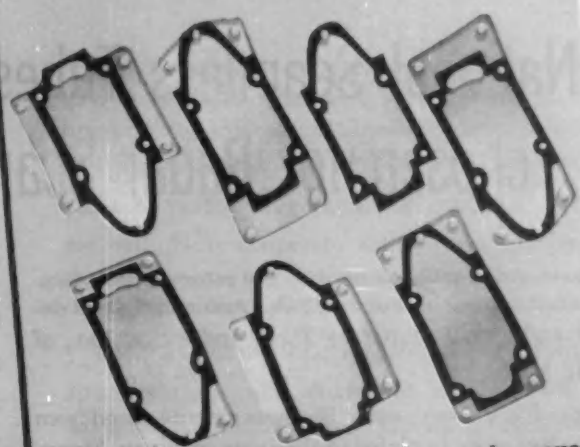


Versatility Plus! Simple adjustment of return spring positioning plate determines position of the movable contact in the "free" position. Equally simple adjustment of latches makes switch either single acting, or double acting with neutral position . . .

11 switches in 1 . . . all you need is a screw driver!

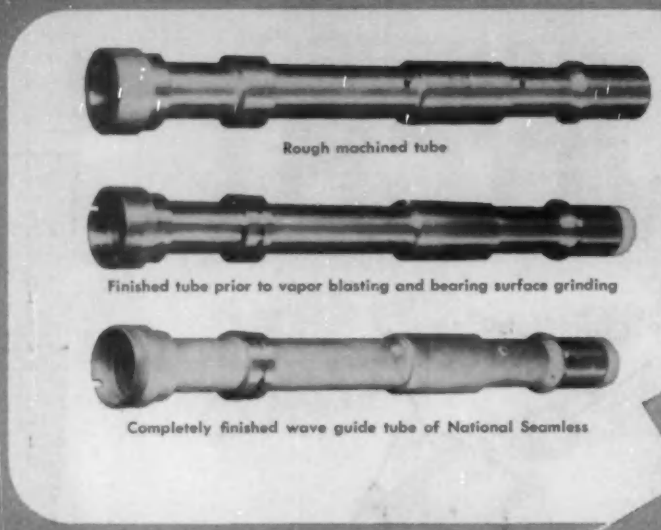
Adjustable! Operating lever arm position is continuously adjustable and provides up to 80° overtravel unless limited by enclosure. An outstanding Square D design feature.

No Inventory Problem! Square D's basic switches and lever arms are separately packaged for your stocking convenience. A moderate stock covers a multitude of possible combinations.



Easy Mounting! Square D provides seven different base plates, plus side mounting holes. It's easy to mount switches in a variety of positions.

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS



Rough machined tube

Finished tube prior to vapor blasting and bearing surface grinding

Completely finished wave guide tube of National Seamless

No other material could do the job . . . . .

National Seamless Tubes of USS Stainless Steel chosen for Radar Scanner Wave Guide Tube

The wave guide tube, along with the rotor control, form the central control unit of the Radar Antenna System designed and manufactured by Davis Industries, Inc., of Detroit, Michigan.

Originally, the wave guide tube was manufactured from carbon steel suitably plated to eliminate corrosion. Manufacturing complications and plating difficulties proved this process economically unsound and operationally hazardous. That's why NATIONAL Seamless Tubes of USS Stainless Steel were specified. The 1⅛" I.D., ½" wall seamless USS Stainless Steel tubes offered a clean job that required no plating and solved the corrosion problems. In addition, only seamless steel tubing could meet the weight and strength factors required.

The superior strength, consistent uniformity, and dimensional accuracy of NATIONAL Tube's Seamless Steel Tubing make it ideal for all types of vital applications. It is available in a wide range of diameters, wall thicknesses, various shapes and steel analyses, and is produced to exacting standards by the world's largest manufacturer of tubular steel products. Upon request, our engineers will be glad to make a study of your requirements, and help you apply Seamless Steel Tubing to your particular specifications.

SEE The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)

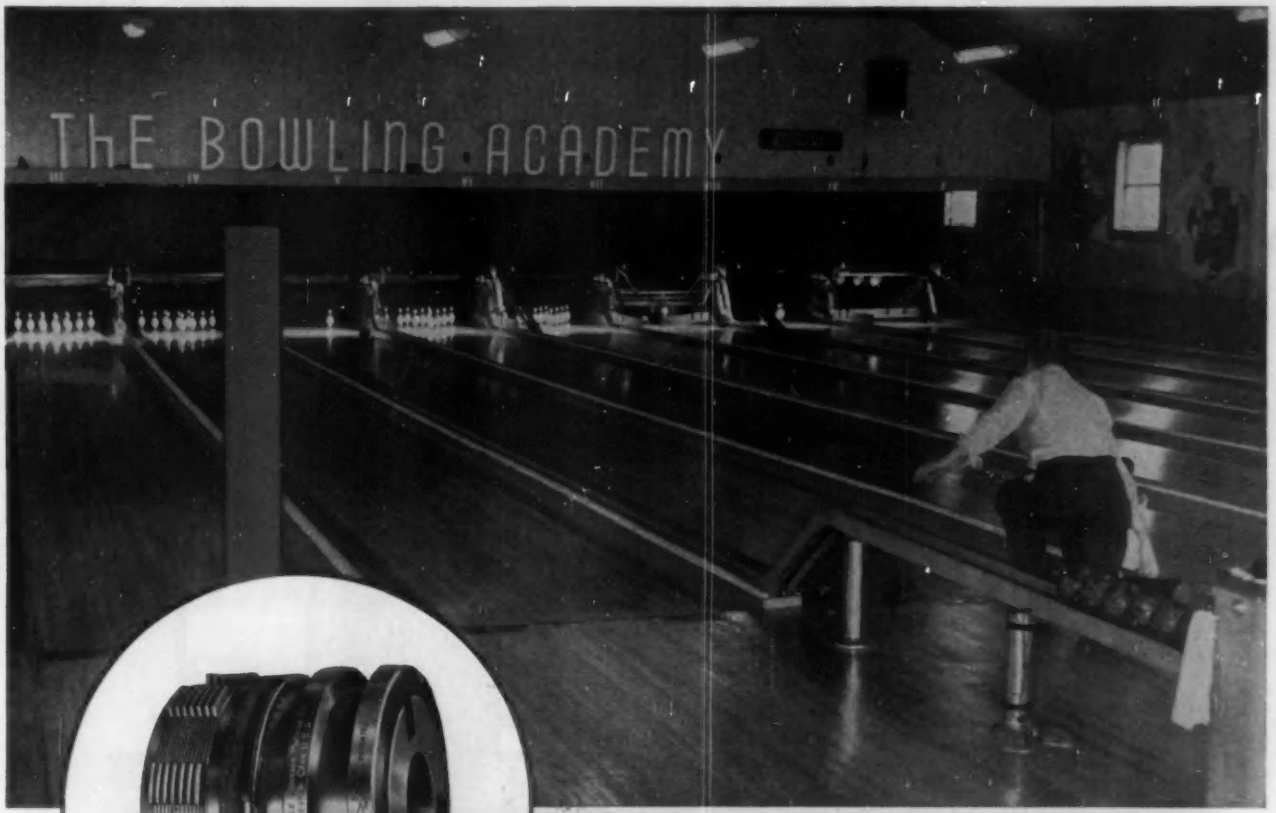
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

WALLS WITHOUT WELDS

NATIONAL SEAMLESS STEEL TUBES

UNITED STATES STEEL



AUTOMATION ON THE ALLEYS

controlled by MAXITORQ CLUTCHES

The photograph above shows the first installation by Sherman Enterprises, Inc., Worcester, Mass., of their automatic PINSETTER.

The pin boys have been replaced by this ingenious mechanism, a part of which is accurately controlled by Maxitorq floating disc clutches. Two solenoid-operated No. 22 clutches control (1) the elevator pick-up and setting of pins to correct position and (2) operate the distributor conveyor which carries forward the sorted pins. Alleys No. 2 and 10 show the automatic pin sweepers that clear the alleys for re-setting. Bowling balls are also automatically returned.

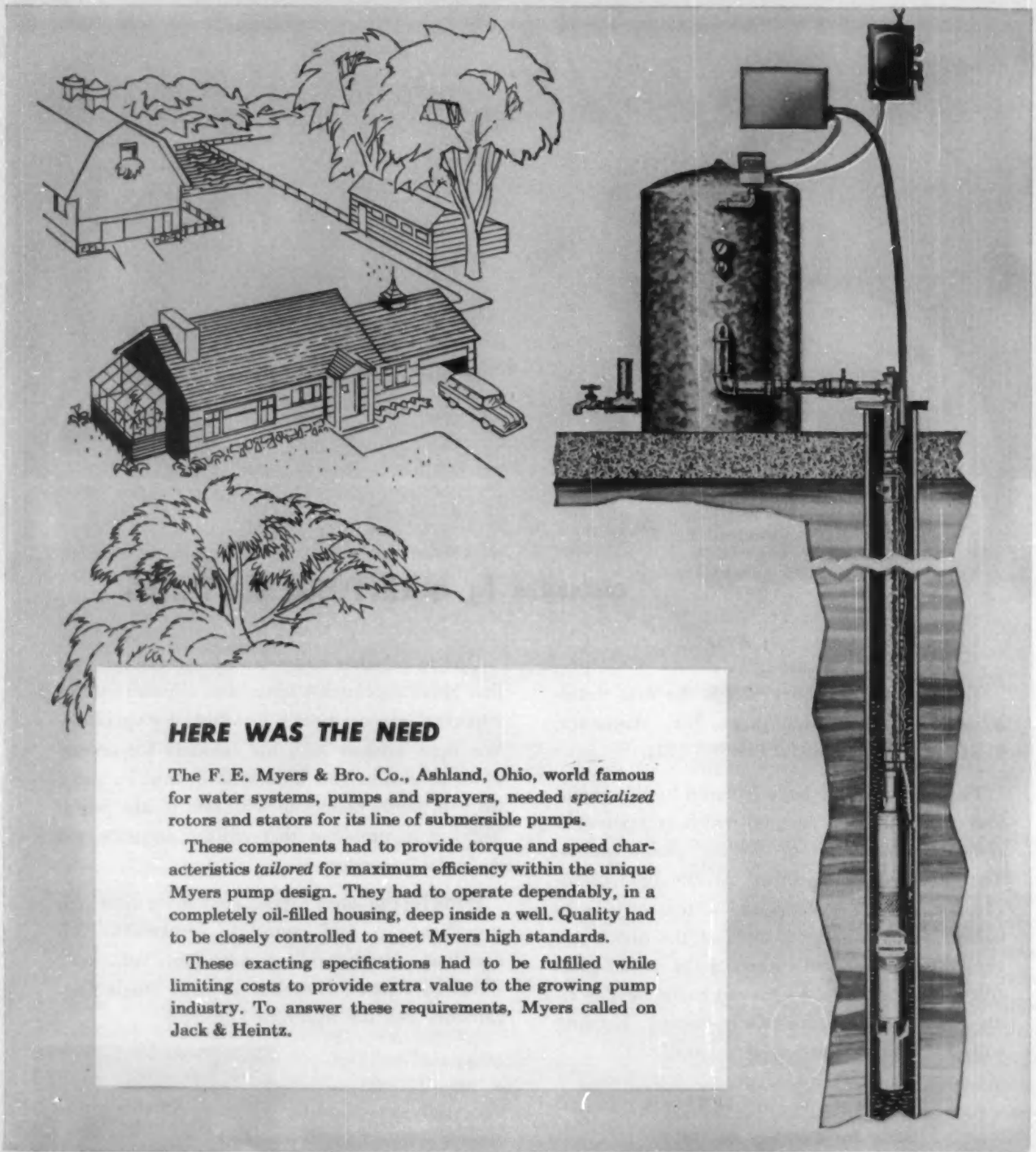
Carlyle Johnson engineers are greatly pleased that Maxitorq clutches have been selected for this important improvement in bowling alley operation. We have worked with the builders for several years to perfect this automatic control . . . and we will gladly cooperate with you in any power distribution problems that require accurate and dependable service.

Write for our latest catalog containing drawings, specifications and complete information on Maxitorq Multiple Disc Clutches, Automatic Overload Release Clutches, Johnson Single Disc Clutches and the Maxitorq Disc-Pac.

Send for Catalog No. PE-7.

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

Jack & Heintz supplies customized



HERE WAS THE NEED

The F. E. Myers & Bro. Co., Ashland, Ohio, world famous for water systems, pumps and sprayers, needed *specialized* rotors and stators for its line of submersible pumps.

These components had to provide torque and speed characteristics *tailored* for maximum efficiency within the unique Myers pump design. They had to operate dependably, in a completely oil-filled housing, deep inside a well. Quality had to be closely controlled to meet Myers high standards.

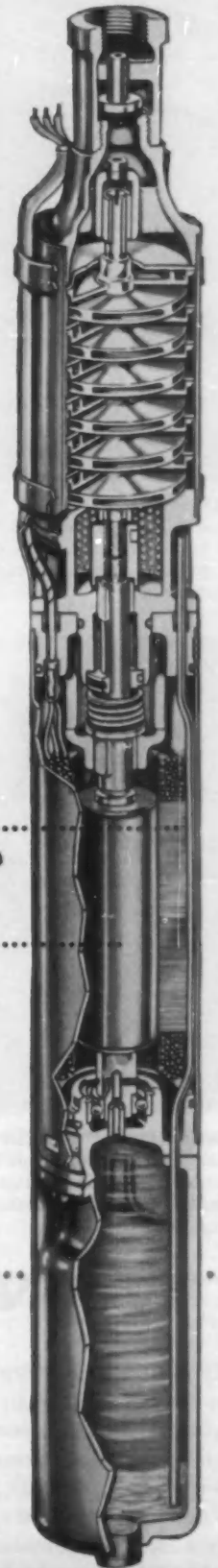
These exacting specifications had to be fulfilled while limiting costs to provide extra value to the growing pump industry. To answer these requirements, Myers called on Jack & Heintz.

Customized ELECTRIC

motor components for

Myers

Submersible Pumps



Jack & Heintz accepted the responsibility of designing and manufacturing basic customized motor components in accordance with the typically high standards of the Myers-built pumping unit—designed to work under water for thousands of service-free hours.

STATOR

Special windings were designed to furnish the exact operating characteristics to meet the Myers specifications. Special insulating materials were developed, completely impervious to the oil in which they operate.

ROTOR AND SHAFT ASSEMBLY

The rotor was developed with the maximum amount of copper to achieve the highest possible speed at full-load torque. Silver alloy induction brazing makes it an indestructible mass. Tolerances on the rust-resistant shaft are held strictly to Myers specifications . . . with precision balancing to prevent vibration.

In addition, highly specialized methods and processes were developed by Jack & Heintz to provide manufacturing economies consistent with the needs of an expanding market for Myers submersible pumps.

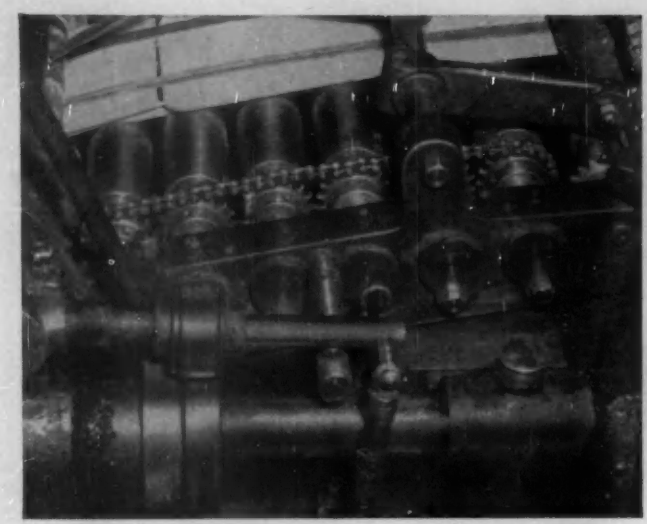
DESIGN YOUR PRODUCT TO DO A JOB . . .

not to fit a motor

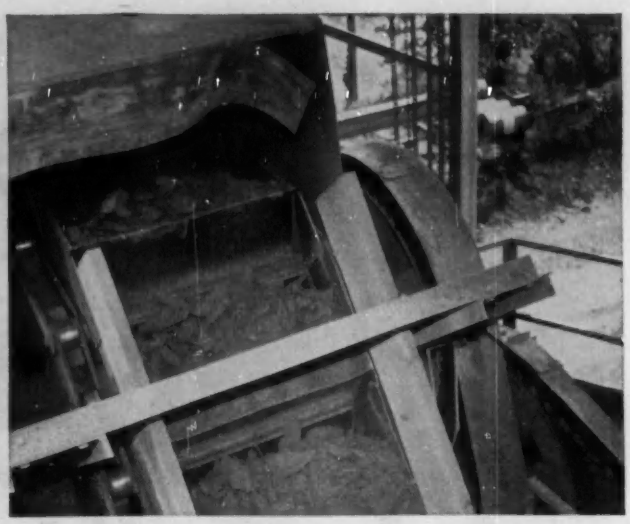
Avoid compromising your product design by taking advantage of an engineering philosophy that will answer your special motor needs. Design your product to do a job . . . *not to fit a motor!* Write Jack & Heintz, Inc., 17627 Broadway, Cleveland 1, Ohio.

© 1955, Jack & Heintz, Inc.

MOTORS *by* JACK & HEINTZ



COSTS CUT . . . SPACE SAVED in a paper bag making machine. The CHAIN Belt Man recommended the replacement of 14 gears with a Rex® Roller Chain. Seven shafts eliminated . . . performance improved . . . rapid wear on gears and bearing eliminated.



DOWN TIME REDUCED in a bucket elevator. CHAIN Belt Man applied Chabelco® Steel Chains to overcome premature chain failure caused by shock loads, dirt, dust and heat. Built-in clearances of this chain provided efficient answer . . . cut down time.

HANDLING COSTS CUT in automotive plant. CHAIN Belt Man specified Rex TableTop® Chain to carry axle parts from hardening furnace to assembly line. Low-cost conveyor chain handles hot parts efficiently . . . rugged construction assures long life.

IMPROVED PERFORMANCE . . . LOWER COSTS of lift chains on fork truck due to CHAIN Belt Man's recommendation of Rex Leaf Chains. Standard roller chains used originally cost more . . . did not have strength or life of leaf chains for this service.

No Need to Do It Yourself . . .

Why not take advantage of the selection and application service offered by your Chain Belt Field Sales Engineer? With his broad background of experience in engineering chain drives and conveyors, he can help you save time, cut costs, improve product performance.

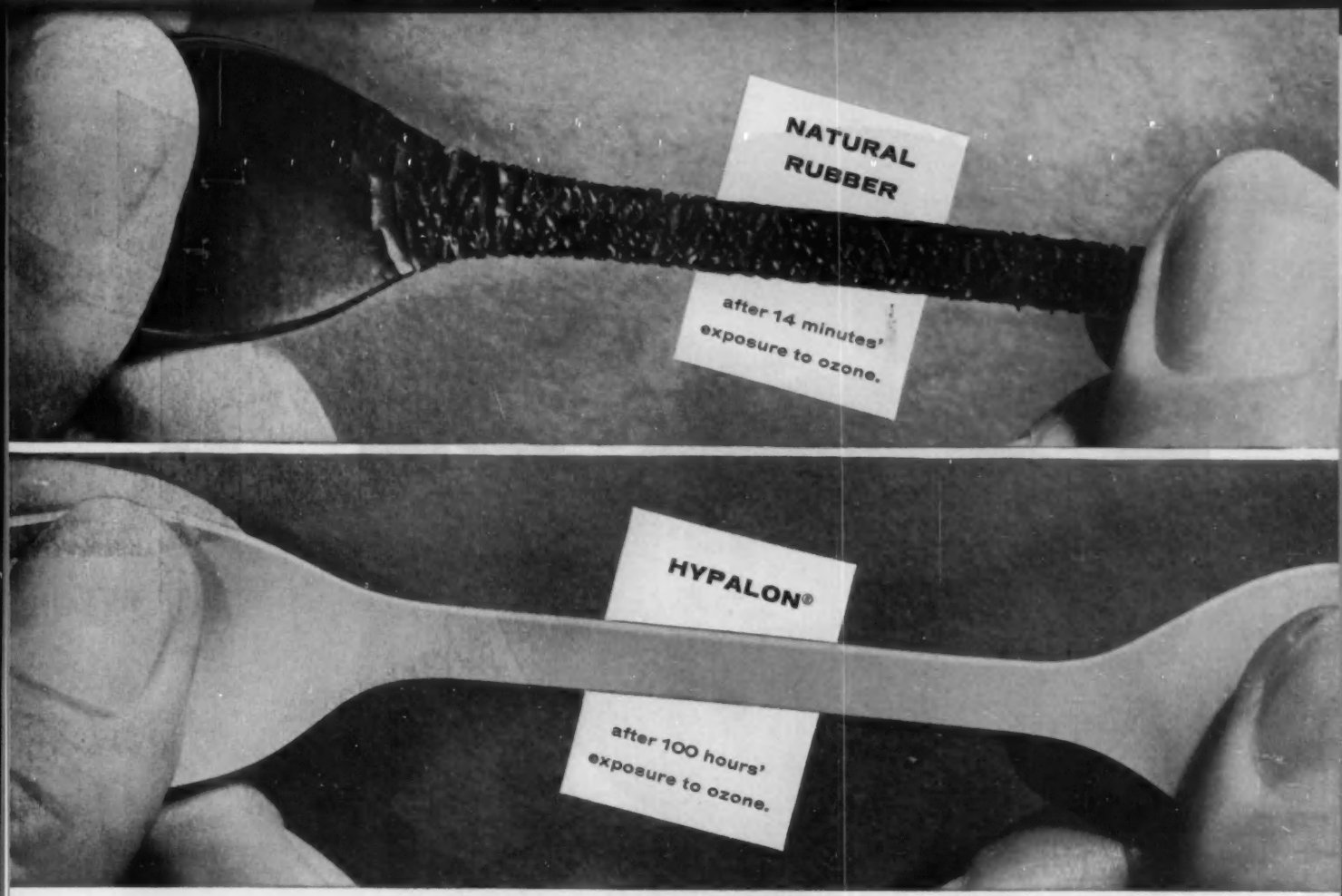
Your Chain Belt Man is more than a salesman . . . he's a chain application engineer. He knows your problem because he has solved similar problems. Backed by a complete line of chains, attachments, sprockets, roller bearings and related power transmission machinery, he can be an "extra man" for your engineering department . . . help you arrive at the one best answer for your problems.

If you have a chain application problem, call your Chain Belt Man. Or, write CHAIN Belt Company, 4715 W. Greenfield Ave., Milwaukee 1, Wisconsin.

AT YOUR SERVICE
To help you with chain drive and conveying applications
YOUR CHAIN Belt Man

CHAIN BELT COMPANY

District Sales Offices in all principal cities

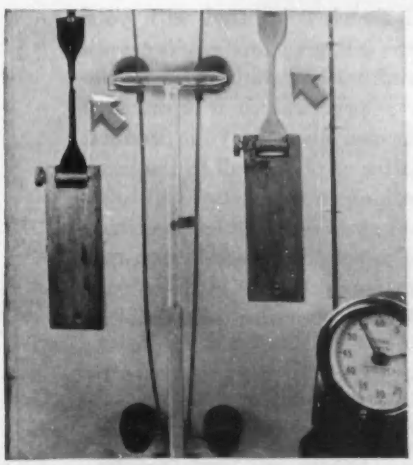


(UNRETOUCHED PHOTOGRAPHS)

NEW CHEMICAL RUBBER

DU PONT HYPALON®

is completely resistant to ozone attack



Ozone Generator. Note "Dumbbell" of HYPALON (right) in perfect condition. Natural rubber (left) ready to break after 14 minutes.

Important news for engineers and designers! Tests show that HYPALON, Du Pont's new chemical rubber, is completely unaffected by ozone. Sustained exposure to ozone concentrations as high as 150 p.p.m. has produced no cracking or weakening, no change in original properties.

When your product requirements call for a resilient material having exceptional durability, consider HYPALON. In addition to its complete resistance to ozone, HYPALON can withstand a wide range of conditions that cause failure in ordinary rubber. For example:

HYPALON has exceptional heat resistance. HYPALON can operate at temperatures as high as 350°F. depending upon exposure conditions.

HYPALON has excellent chemical resistance. It resists oxidizing chemicals as well as many others.

HYPALON has superior color stability. Bright colors *stay* bright despite exposure to sunlight and weather.

HYPALON resists oil, grease, abrasion, flame and flex cracking. Almost all manufacturers who make rubber products can produce products of HYPALON. Current uses include hose, coatings for fabric, rubber, wood, and metal; gaskets, tank linings and molded and extruded parts. Be sure *you* get full details about HYPALON.

SEND FOR FREE BOOKLET. Here's your introduction to HYPALON—its properties and uses. Learn how *you* can use this new chemical rubber to make a better, more durable product. Just clip coupon below for your copy.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, PE-7
Wilmington 98, Delaware

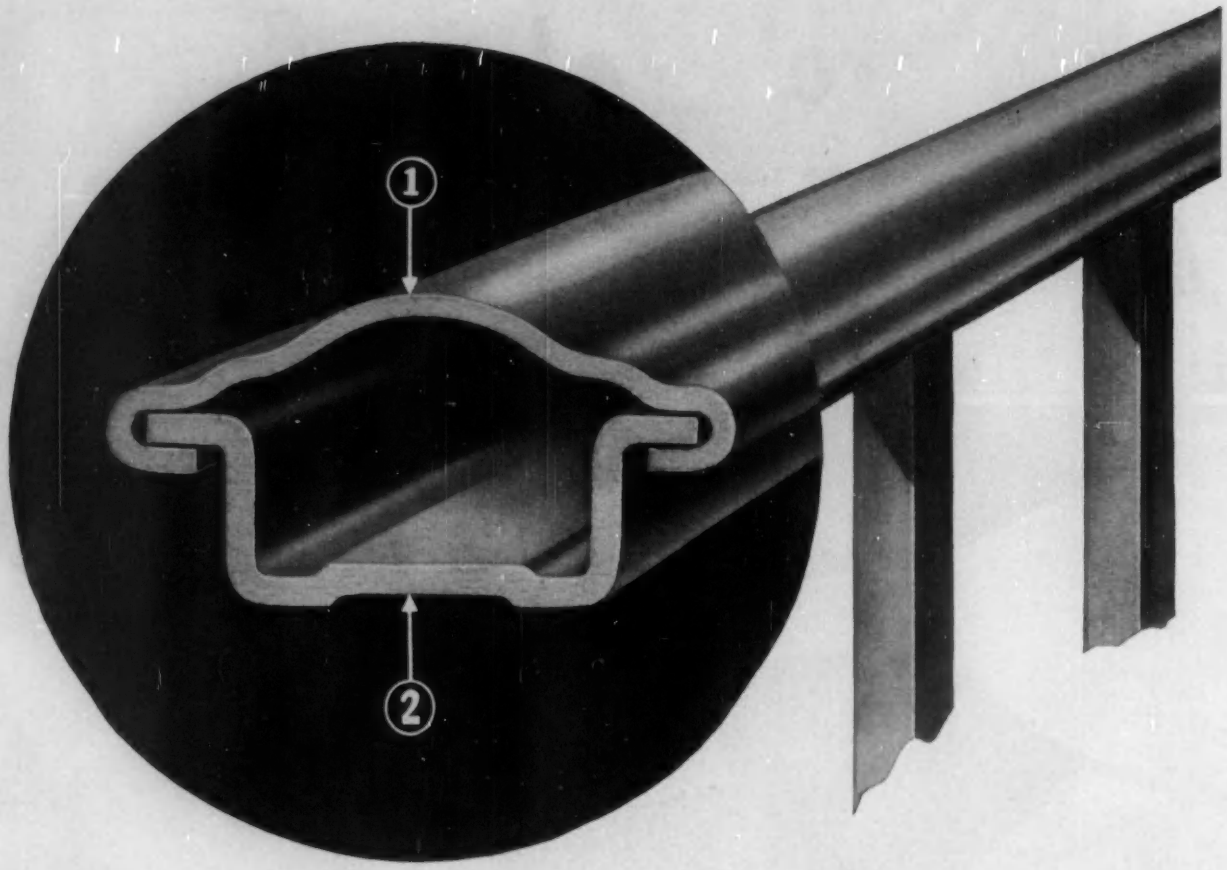
Please send me your folder on the properties and uses of "HYPALON."

*Name*_____ *Position*_____

*Firm*_____

*Address*_____

*City*_____ *State*_____



How they saved by making this railing hand grip from Cold-Formed Shapes

These Bethlehem Cold-Formed Shapes, known as (1) the hand-rail cap, and (2) the top channel, are used by a leading maker of ornamental railings. The channel fastens to the top of the pickets and the cap slides over it to form a sturdy, long-lasting hand grip. Using rolling machines, we make these shapes from strip steel in 24-ft lengths.

By using Bethlehem Cold-Formed Shapes this manufacturer saves in several ways. He has no need to tie up labor and shop time in cutting and bending. He avoids having to carry large inventories, for we make the shapes and ship them as needed. And since he receives the shapes in the exact dimensions he requires, he has no problem of scrap disposal.

COLD-FORMED SHAPES IN YOUR PRODUCT

There's a good chance that you could use Bethlehem Cold-Formed Shapes to advantage. The range of possible applications of these shapes is almost limitless. Overhead-garage-door tracks, storage racks, industrial conveyor systems—these are just a few of many recent applications.

Bethlehem Cold-Formed Shapes come in any gage of strip, sheet or plate steel from 5 to 24. A simple pencil sketch submitted with your inquiry will give our engineers all the information they need to develop a practical and economical cold-formed shape for your product.

A letter or phone call to the nearest Bethlehem sales office will bring you a copy of our booklet describing Cold-Formed Shapes. Or our representative will be glad to call and discuss your needs in detail.

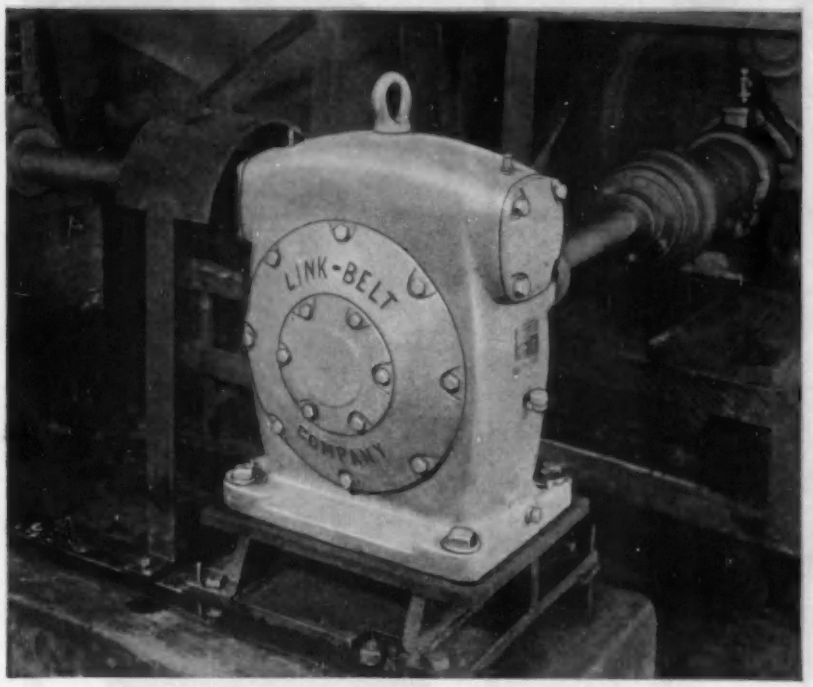
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Here's industry's most comprehensive line of WORM GEAR DRIVES



Reel at the wind-up end of paper machine is driven through a dependable Link-Belt Worm Gear Drive.

Type WB — Single reduction, worm below gear, horizontal output shaft.

Type WV — Single reduction, vertical output shaft (up or down).

Type HWB — Helical gear first reduction, worm gear final reduction. Worm below gear, horizontal output shaft.

Type HWV — Helical gear first reduction, worm gear final reduction. Vertical output shaft (up or down).

Type DWB — Double worm reduction gear, horizontal output shaft.

Type DWV — Double worm reduction gear, vertical output shaft (up or down).

Type WVS — Single reduction, worm on top of gear, horizontal shaft with screw conveyor flange.

Type WVT — Single or double reduction overhead conveyor drive.

FOR efficient, high-ratio, right-angle speed reductions, choose from the complete Link-Belt line of worm gear drives. A wide selection of single-worm, double-worm and helical-worm gear reductions assures you of the best drive for large and fractional horsepower requirements.

All three types are available with horizontal and vertical housings to permit convenient, compact connections to prime movers and driven machinery. And a choice of two shaft diameters facilitates direct connection or the accommodation of heavy overhung loads.

Single Worm Gear Drives are offered in ratios from $3\frac{1}{10}$:1 to 100:1 with output capacities up to 97.9 hp.

Helical Worm Gear Drives are available in ratios from 26:1 to 540:1 — output capacities up to 56.7 hp.

Double Worm Gear Drives have ratios from 26:1 to 8000:1—output capacities up to 26 hp and 124,800 inch pounds torque.

Get all the facts on Link-Belt Worm Gear Drives. Contact your Link-Belt office or authorized stock-carrying distributor. Or write today for Book 2324-A.

LINK-BELT

ENCLOSED DRIVES

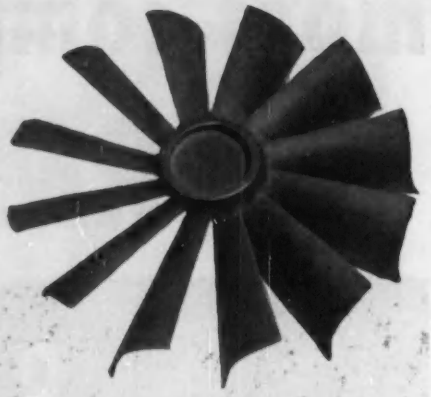
13.873

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

Mass-Produced at Less Cost...

by HAYNES Investment Casting

Trade-Mark



PRODUCED FOR 74 PER CENT LESS

Originally this turbine wheel was machined from a 20-lb. forging to a final weight of a little over 1 lb. Now the part is produced by investment casting and only 2 oz. of metal is removed. Investment casting has brought about a 74 per cent reduction in production costs by saving strategic metal and machine time.

COST CUT 60 PER CENT

This investment-cast motor mount was made in a high-strength alloy at 60 per cent less than the cost of a forging. The mount bears the entire weight and torque of a 100-lb., 15-horsepower aircraft starter motor. The investment-cast parts require only four simple finishing operations.

ASSEMBLY COSTS REDUCED

Investment casting made it possible to produce this cylinder head in one piece, eliminating extra assembly costs. Machining was reduced to a minimum. The design of the part is special to investment casting. The castings weigh about 25 lb. and are 7 in. in diameter.

HAYNES *investment castings can solve some of your own production problems. For more information, contact the nearest Haynes Stellite Company office listed below.*

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.

HAYNES INVESTMENT CASTINGS

TRADE-MARK

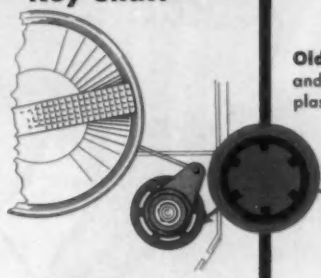
Sound, dense, high-strength parts available in cobalt-base alloys, nickel-base alloys, iron-base alloys, stainless steels, and alloy and carbon steel.

Haynes Stellite Company
A Division of
Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago — Cleveland — Detroit — Houston
Los Angeles — New York — San Francisco — Tulsa

5 Waldes Truarc Rings simplify assembly, eliminate parts, bring big over-all savings to new design low-cost camera

Anscoflex II Camera

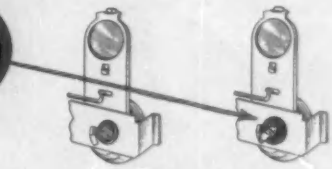
Key Shaft



Parts originally designed for self-locking Truarc ring (series 5105). Some cameras in the past had brass cup staked to the body. At times staking operation cracked the plastic, resulting in loss of expensive part.

Portrait and Filter Lens Knob Assemblies

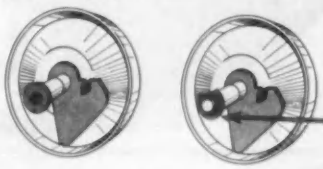
Old way: Knob with plastic shaft used washer and heat forming operation that flattened the plastic pin and locked the pivot in position.



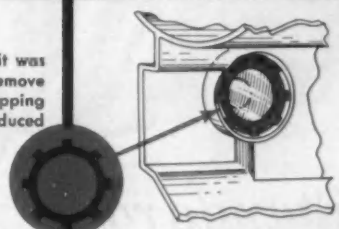
Truarc way: Molded plastic knob with pin is easily and quickly held by a Truarc self-locking ring (series 5105). No groove is necessary. Washer is eliminated and it is possible to remove ring if necessary without damage to knob.

Winding Knob

Old way: With screw and washer design, it was necessary to disassemble entire camera to remove screw which secured winding knob. Self-topping screw sometimes failed to secure knob, produced excessive end play.



Truarc way: Truarc "E" ring (series 5133) allows removal of winding knob without major disassembly of camera, reducing repair time. Use of stacked rings and Truarc applicator saved $10.40 per M on labor. Material saving: $2.29 per M.

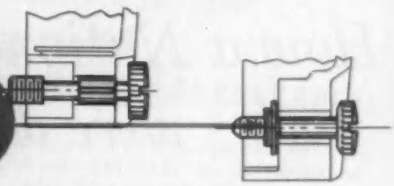


Rear Lens

Parts originally designed for self-locking Truarc ring (series 5005) Some cameras in the past had glass element secured by heat forming tabs from plastic body. Loose or chipped elements resulted in loss of both parts.

Flash-Gun Case Assembly

Old way: In the original design a sleeve was wrapped around neck of screw and pressed into hole of plastic cover. Close working areas made assembly difficult and required extra operation to lock ring into place.



Truarc way: Series 5133 E-Ring snaps onto unthreaded shank of screw quickly, needs no special groove. Labor saving $7.06/M.

Ansco, Binghamton, N. Y., uses the latest technical advances in construction to produce an economical, easy-to-use reflex camera. 5 Waldes Truarc Rings are used in this new design to save material and labor costs, eliminate parts, simplify assembly and reduce rejects.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting . . .Waldes Truarc Grooving Tool!

WALDES
TRUARC®
RETAINING RINGS

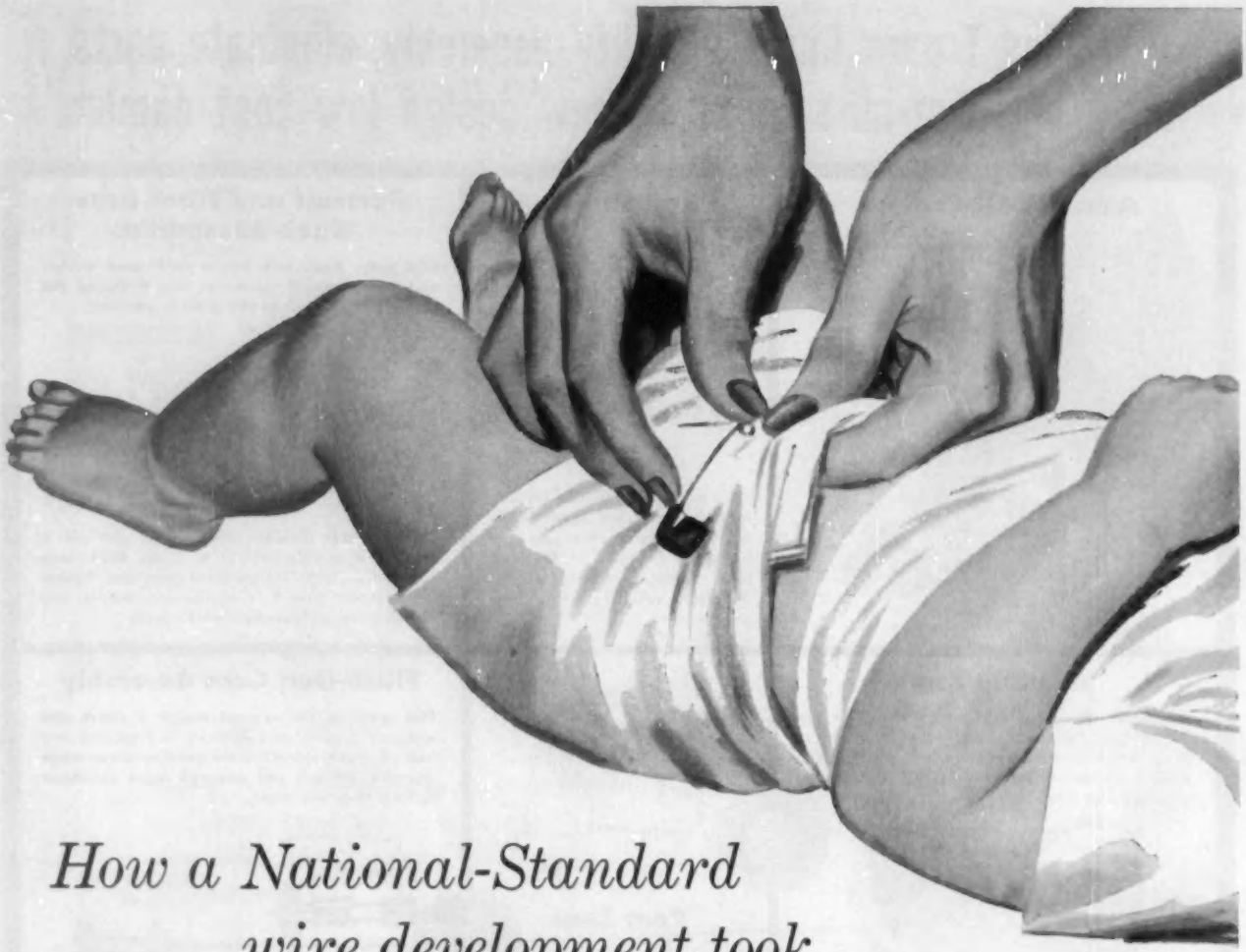
Send for new catalog supplement

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

*Name*_____
*Title*_____
*Company*_____
*Business Address*_____
*City*_____ *Zone* ____ *State*_____

PN077

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.



How a National-Standard wire development took

A BETTER "REEF" IN BABY'S PANTS

● Almost any product can be made better. Take safety pins.

A prominent manufacturer came to National-Standard with this idea: "Give us," he said, "a polished wire that needs no plating, yet won't corrode . . . a better, stronger, springier wire to which we can attach a plastic head."

A National-Standard research team took on the problem . . . and produced a special stainless steel wire with a mirror finish that needed no further polishing. They gave it magnetic properties so that bits of steel could be easily removed from the plastic compound used for heads . . . to protect costly dies and equipment. They gave it a special temper that made it springier, tougher, yet still easy to form.

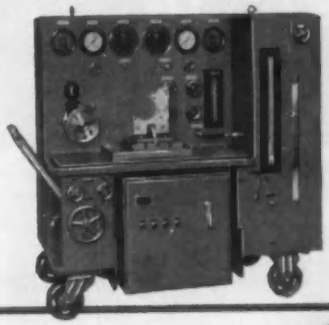
Thousands of manufacturers have learned to depend on National-Standard for development and manufacture of special types of wire, wire cloth and strip steel . . . fussy, hard-to-make products that many companies hesitate to tackle. Why not give us a call and see what we can do for *you*.

NS NATIONAL-STANDARD Company NILES, MICHIGAN

NATIONAL-STANDARD COMPANY • NILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape
ATHENIA STEEL DIVISION • CLIFTON, N. J.
Flat, High Carbon, Cold Rolled Spring Steel
REYNOLDS WIRE DIVISION • DIXON, ILLINOIS
Industrial Wire Cloth
WAGNER LITHO MACHINERY DIVISION • JERSEY CITY, N. J.
Special Machinery for Metal Decorating
WORCESTER WIRE WORKS DIVISION • WORCESTER, MASS.
Round and Shaped Steel Wire, Small Sizes

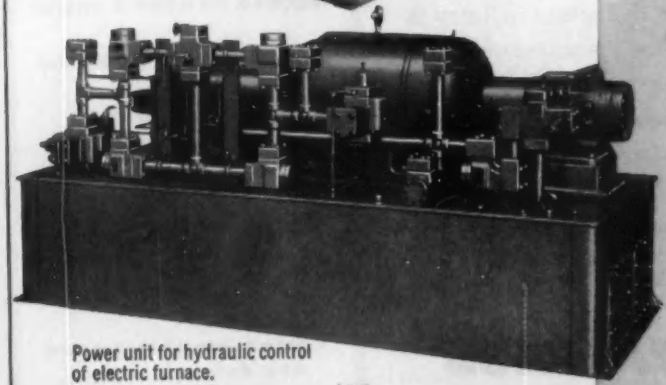
Pulpit type power unit provides full visibility, easy accessibility.

Compact power unit showing gasket-mounted valves.



Portable power unit for testing pumps.

Power unit with gasoline engine as prime mover.



Power unit for hydraulic control of electric furnace.

6837

Individually Designed to Meet *SPECIFIC* Needs

VICKERS®
Custom Built
HYDRAULIC POWER UNITS

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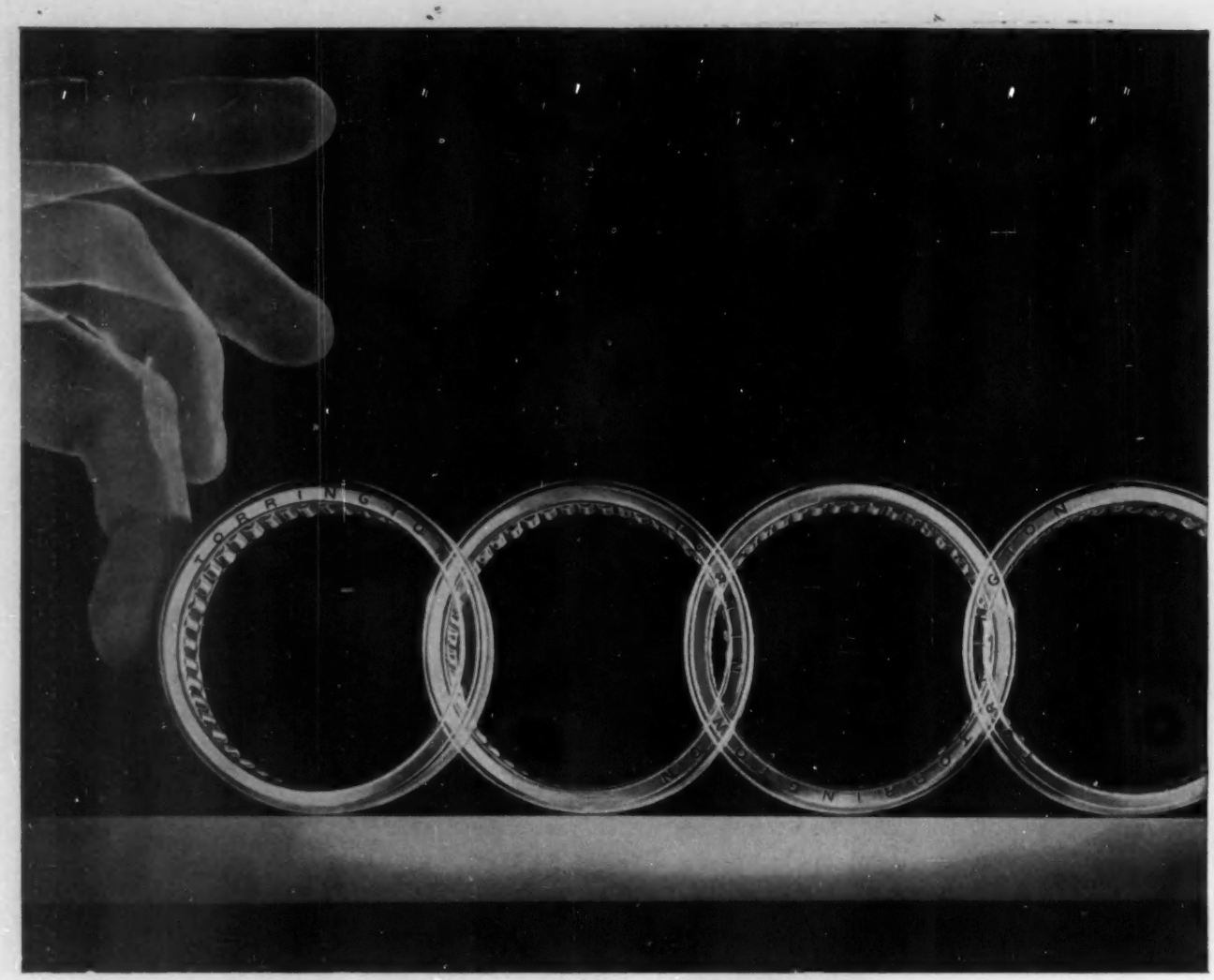

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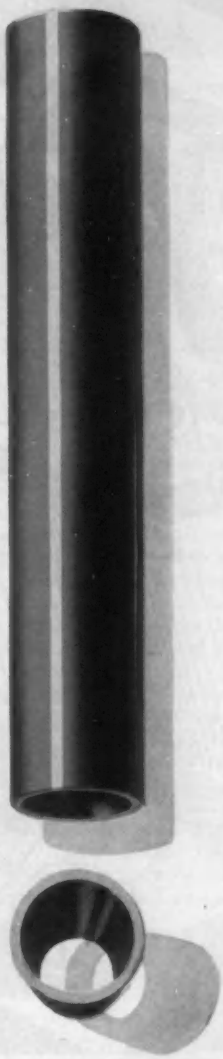

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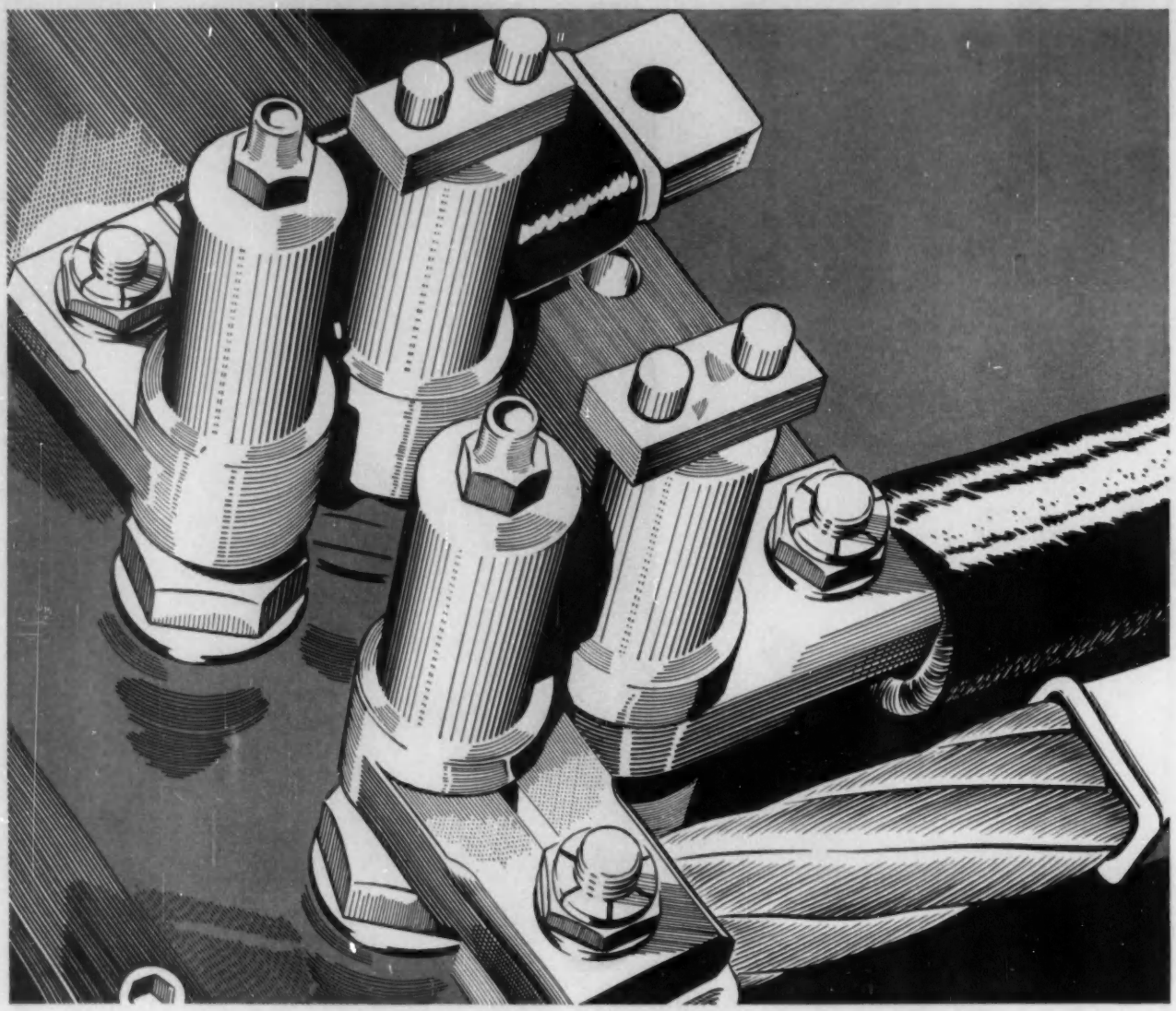
FLEXLOC AT WORK



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Nuts that loosen cause trouble. Contact is poor; flow of current erratic; welding faulty—and faulty welding means inferior finished jobs.

Don't take any chance of nuts loosening on vital assemblies. FLEXLOCS are made to stay put. And they are available in a wide range of sizes, types and material. See your authorized industrial distributor for Bulletin 866 and samples. Or write STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

• • •

Use FLEXLOCs anywhere safely

ON ROUGH BOLTS. They'll smooth out bolt threads without damaging the threads of the nut.

IN TEMPERATURES TO 550°F in plated nuts and even higher in unplated ones. High temperatures do not affect FLEXLOCS. Nuts with non-metallic inserts fail under such conditions.

AS STOP OR LOCK NUTS. After at least 1½ threads of a standard bolt are past the top of the nut, the FLEXLOC stays put.

REGARDLESS OF MOISTURE, OIL, DIRT OR GRIT. None of these conditions make any difference to a FLEXLOC, and vibration won't loosen it.

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'55 Forecast: MORE ALUMINUM PRODUCTS THAN EVER BEFORE

Reynolds

ALUMINUM REPORTER

MODERN DESIGN HAS ALUMINUM IN MIND

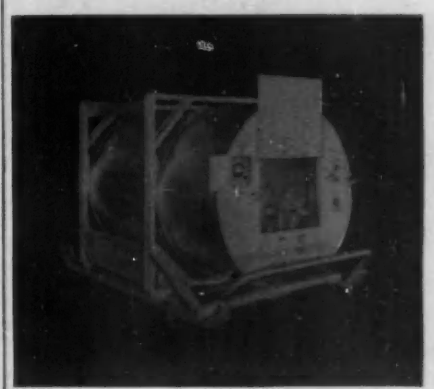
★ ★ ★ Eighteenth in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

HELIARC-WELDED LOX TANKS HOLD 50 MICRON VACUUM AT −300° F

Ronan and Kunzl, Inc., of Marshall, Michigan, is now manufacturing Liquid Oxygen Containers for industry, designed to Air Force specifications and made of Reynolds Aluminum.

Since these containers must be light in weight and still withstand extremes of both temperature and vacuum, choice of the metal to build them was of utmost importance. Aluminum was selected because it remains ductile at −300°F temperatures. Only a metal that retains its ductility could withstand the thermal shock to which these containers are subjected. And aluminum alone met the rigid strength per pound requirements of the Air Force.

To keep oxygen at sufficiently low temperature to retain its liquid state in storage or transfer, the Ronan and Kunzl LOX tanks were designed like large vacuum bottles using the principle of the Dewar bottle. A double-walled container is built to sustain a high vacuum which provides an insulating effect of great efficiency. Heliarc welded aluminum successfully withstands a vacuum below 50 microns over long periods of use. Still another indication of aluminum's great strength is the container's built in "pressure build-up" system for force discharge of the tank's contents. Pressure build-up is accomplished by permitting some of the liquid content to pass through a built-in coil in which it gasifies. The resultant pressure (up to 50 psi in six minutes exerted on an aluminum wall having a 50 micron vacuum on its opposite side) forces the liquid contents out of the tank. Controls, valves and gauges assure safe storage and easy transfer of liquid oxygen and other gases handled in a liquid, low temperature state.



The 150 gallon Ronan and Kunzl LOX Container on skids, illustrated, is approximately 8½ feet long, 4½ feet high and 4 feet wide. It weighs 890 pounds empty, about 1440 pounds when filled. 50 and 500 gallon models are proportionate in size and weight. Tanks, framework and supporting skid are all made of aluminum. Selection of the several alloys for various parts was based on the recommendations of Reynolds Engineering Service. These containers are considered the most efficient made, with the lowest evaporation ever attained in units so large.

For information on how welded aluminum can solve design and production problems for *you*, send on your business letterhead for the free 186-page technical manual, "Welding Aluminum and Aluminum Alloys". Write to: *Reynolds Metals Company, P.O. Box 1800-HR, Louisville 1, Kentucky.*

Non-Corrosive Aluminum Makes Possible Built-in Washing Unit for Trion Electronic Air Filters

Aluminum ionizing-collecting cells in the Trion Electronic Air Cleaner are automatically washed once a week for a period of 15 minutes. A single property of aluminum—resistance to corrosion—makes this built-in washing feature practical.

As in this case, one aluminum advantage often completely justifies its use. Yet there are invariably other clear-cut benefits. Aluminum is also used because of its high conductivity to weight ratio; and its easy workability is another advantage. While light weight is its primary advantage, aluminum's strength also adds to its usefulness.

If Trion's use of Reynolds Aluminum points out possible new aluminum applications in the solution of production or performance problems for your products, call on Reynolds Engineering Service for assistance.

Reynolds engineers will work with your staff and provide them with the latest information on designing and fabrication literature. *Reynolds Metals Company, P. O. Box 1800-HR, Louisville 1, Kentucky.*

Fabricated Aluminum Products Improved by Use of Aluminum Fasteners

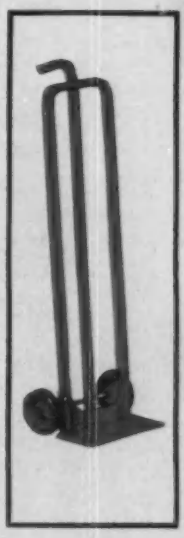
To preserve the outstanding advantages of aluminum in assembled products, best results are usually obtained through use of aluminum fasteners. Rivets, screws, bolts, nuts, nails, pins, and many types of special fasteners are made by a large group of reliable manufacturers.

Use of aluminum fasteners maintains the rustproof, corrosion resistant, lightweight qualities throughout your aluminum products —prevents discoloration and breakdown because of rust and corrosion.

A list of manufacturers who rely on the high quality of Reynolds Aluminum for their fasteners will be sent to you on request. Write to *Reynolds Metals Company, P.O. Box 1800-HR, Louisville 1, Kentucky.* Reynolds technical handbook, "Fastening Methods for Aluminum" will also be sent if you request it on business letterhead.

Honeyman Manufacturing Co. Finds Aluminum Advantages Pay Off in New Hand Truck

The Honeyman Aluminum Hand Truck is so light that picking it up with one hand is a cinch. Yet A. A. Honeyman, president of the Portland, Oregon, firm that designed it, says, "We want to stress the fact that we have sacrificed nothing in strength, but have given additional strength with less weight."



Tubular aluminum, such as that used in the Honeyman Hand Truck, offers a distinct production and cost advantage to the manufacturer. Easy workability of this aluminum stock makes fabrication operations simpler and quicker, light weight greatly reduces stock handling and shipping cost.

In use the Honeyman Hand Truck's lightness makes frequent lifting from the bed of a truck to the pavement a much easier job. Its resistance to corrosion and non-rusting characteristics preserve its strength and good appearance.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

Advertisement

Printed in U.S.A.

(Continued From Preceding Page)

Aluminum in Sash Balance Guaranteed for Life of Building by Caldwell Manufacturing Co.

The Caldwell Manufacturing Company of Rochester, N.Y., makers of the Helix Spiral Sash Balance, guarantee their product for the life of the building in which it is installed.

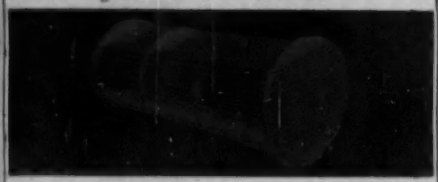
They say, "Seamless, rustproof aluminum tube positively eliminates dust, dirt and other foreign matter from reaching balance interior, thereby increasing the life of the balance many years even under the most adverse conditions."

In addition, the company manufactures a line of clock-spring balances. Over 5,000 sets of this CX-T series, with cast aluminum housings, were used in the UN Secretariat building.

For their Spirex balances, used on wood and aluminum windows in residential construction, Caldwell produces butt seam tubing rolled from Reynolds Aluminum and stresses both appearance and corrosion resistance.

Aluminum Heat Exchanger Tubing Costs Less, Lasts Longer

The original cost of aluminum heat exchanger tubing is considerably less than that of other materials, and because it weighs less, the cost of handling and shipping is lower for both the tubing and complete heat exchangers. Since the ductility of aluminum tubes makes it easy to roll them into tube sheet and to bend, fabricating costs are also reduced.



Add to these cost advantages aluminum's resistance to corrosion by most fluids encountered in heat transfer applications and you get longer life with less maintenance. Among the chemicals to which aluminum is resistant to attack are hydrogen sulfide, ammonia, carbon dioxide and hydrocarbons. Suggested industrial applications for aluminum heat exchangers include compressor intercoolers and aftercoolers, oil coolers, condensers and reboilers.

For complete information on aluminum heat exchanger tubing write to *Reynolds Metals Company, P.O. Box 1800-HR, Louisville 1, Ky.*

Extruded Aluminum Frames Provide Added Strength for DeVac, Inc. Self-Storing Windows

In Minneapolis, where winters are usually long and cold, DeVac, Inc., has scored a great success with their glass walls. Extruded aluminum frames and channels seal out cold air and moisture even on coldest winter days.

De Vac's success is one more example of the problems extruded aluminum can solve. Extrusions give the exact design you need without costly tooling and joining operations. And only aluminum can be extruded so easily, combining light weight, strength and low cost.

For more information on aluminum extrusions, send for the free, 138 page *Reynolds handbook*, "Designing with Aluminum Extrusions". Write for single copies, on your business letterhead, to *Reynolds Metals Co., P.O. Box 1800-HR, Louisville 1, Kentucky.*

Products of De Vac, Inc., bear the famous "Designed by Reynolds Aluminum" Seal. This seal on your product is a mark of extra quality to millions.

WHAT'S NEW

A Quick Look at New Reynolds Aluminum Products and Applications

Technical Advisor No. 28

Devoted entirely to recent developments in aluminum used for electrical conductor, Reynolds Technical Advisor No. 28 is available free to anyone requesting it. It covers latest approved methods for joining aluminum wire, rod, bar, shapes, and cable in electric systems. A question and answer section presents data on determination of cross-sectional area required for a given current; methods of calculating aluminum bus to replace copper; relationship between cold work done on EC aluminum and resulting tempers and tensile strength. Two pages are devoted to new "RABC"—Reynolds Aluminum Bus Conductor—and its conductivity to strength advantages. Analysis of a typical application shows cost advantages.

To get Technical Advisor No. 28 or to place your name on the regular distribution list, send to the address below.

Heat Reflective Fabric

A new process has been developed for coating fabrics with aluminum pigments to provide heat reflection. Assigned U. S. Patent 2,695,895, the new fabric cuts infrared transmission to less than 10% of uncoated fabric, retains flexibility, eliminates strike-through, features improved crock-resistance and is lightweight. These properties can be produced by a printing process at a rate in excess of 40 yards per minute. The printing base is a "leafing" aluminum powder which eliminates the need for shipping heavy finished emulsions. For more information and name of patenting company write to address below.

New Rust-Inhibitive Aluminum Paint

Rust-inhibitive aluminum paint will soon be available from several leading paint manufacturers. It is the result of a rust-inhibitive aluminum pigment developed by Reynolds. The new product is a combination of strontium chromate and powdered aluminum and features the hiding power, reflectivity, and protection of aluminum pigment along with the outstanding rust-inhibitive properties of strontium chromate. The latter is especially useful where salt water exposure is involved.

Results of 3 years exposure

One coat rust-inhibiting aluminum paint — *One coat regular aluminum paint*

Thus, in a single coat, a paint made with this new pigment provides the benefits of a rust-inhibitive primer and a reflective aluminum finish. Write to address below for names of paint manufacturers.

Reynolds Desiccant No. 3

Reynolds announces a new low-cost desiccant with the following typical analysis: 92% Al_2O_3; less than 0.1% SiO_2, Fe_2O_3, and TiO_2. For many applications, including dehydration of gases and liquids, this purity provides very definite advantages over competitive products.

Rolled Square Bar

As a service especially to aircraft, farm equipment and instrument manufacturers, Reynolds has expanded its line of rolled square bars to include sizes 1 5/8" through 2.0" by increments of 1/8". These new sizes are available in specified lengths up to 12 feet and in the following alloys and tempers: 2017-0, -T4; 2024-0, -T4; 5052-0, -F; 6061-0, -T4, -T6; 7075-0, -T6. More complete information available on request to address below.

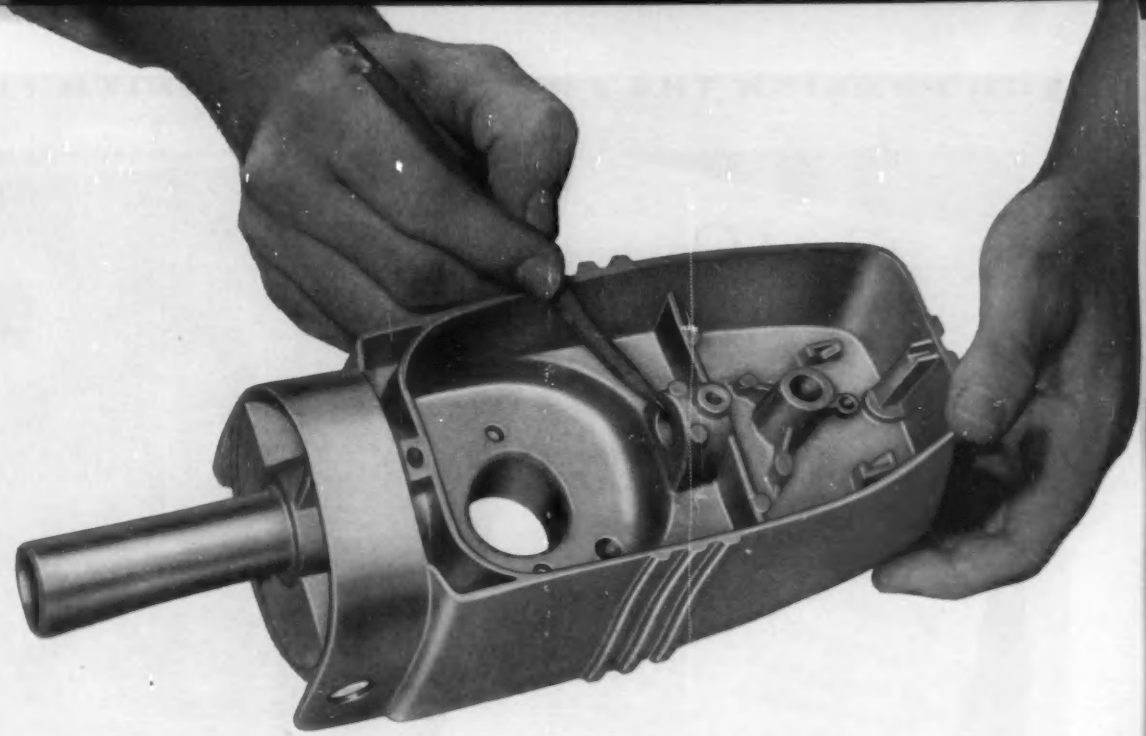
Boral Shielding Development

Reynolds Research Laboratory has done preliminary work on use of Boral as a shielding material to absorb thermal neutrons. Essentially, Boral is a mixture of boron carbide and aluminum, rolled into sheet with a cladding of pure aluminum. When the problems of forming Boral are solved, it can be used to make boxes for enclosing electronic equipment and other radiation sensitive devices.

"Designed In Reynolds Aluminum" Adds Selling Strength to Your Sales Story

This handsome Design Seal on your product has a special significance to millions of American consumers. On your product, made entirely or in part of aluminum, it is an extra mark of quality that helps make the sale.

FOR COMPLETE INFORMATION ON THESE OR ANY OTHER REYNOLDS ALUMINUM PRODUCT, write to Reynolds Metals Company, P.O. Box 1800-HR, Louisville 1, Kentucky



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In 45 years, we have produced many very difficult and unusual die castings here at *Stewart*. However, this is not one of them. Though it includes 3 inserts, this is the "garden variety"—the kind we turn out every day. But to us, no job seems ordinary, because we try to do each one a little *better* than the last. Whatever type of die castings you need—small or large, simple or intricate—with or without inserts—count on *Stewart* to meet your most rigid specifications . . . on time.

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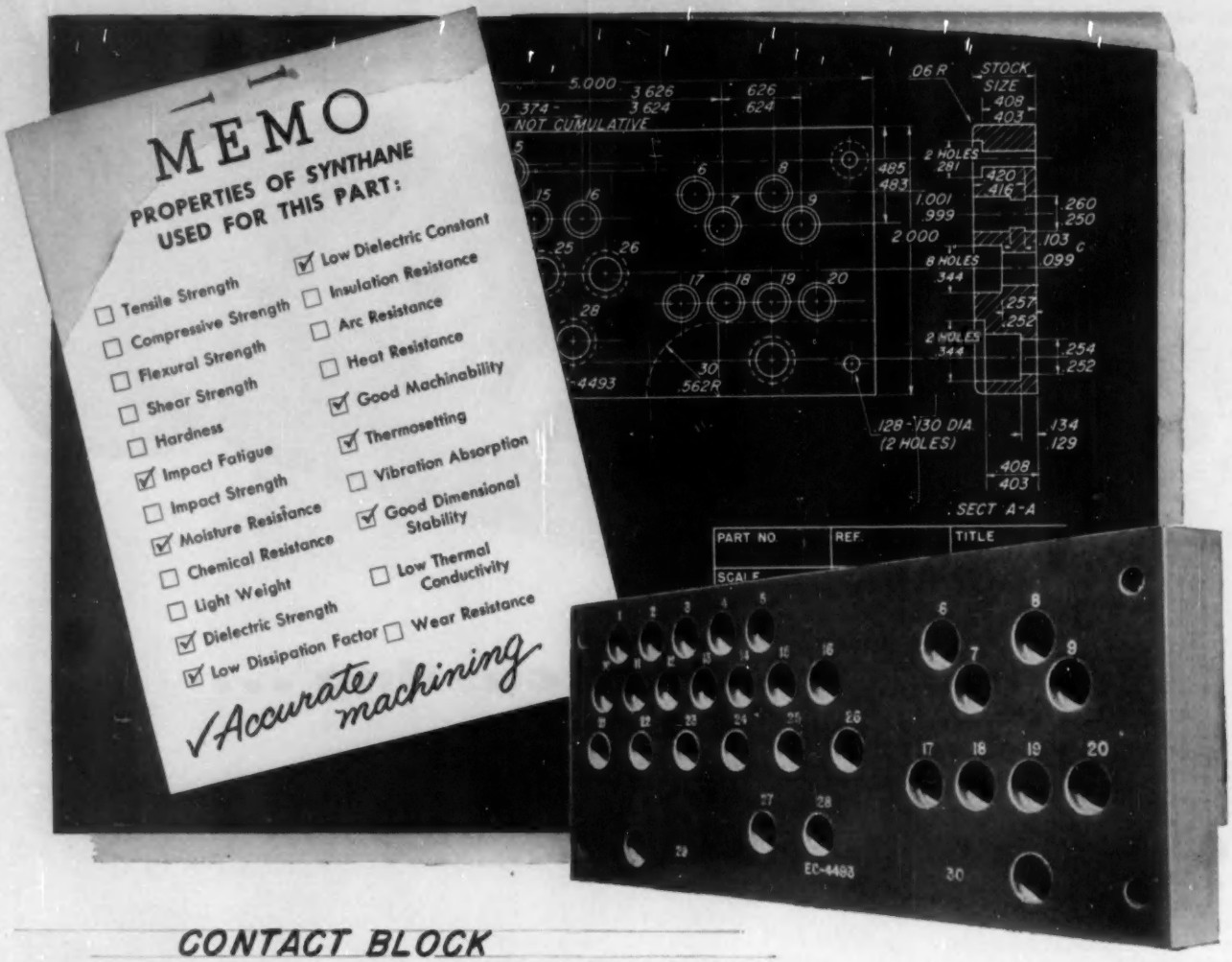

CONTACT BLOCK OF SYNTHANE LAMINATED PLASTIC MEETS MANY ELECTRICAL, MECHANICAL REQUIREMENTS

This contact block—for an electronic device—illustrates the rising demand for materials with many properties in combination. High dielectric strength, mechanical strength and dimensional stability are essential for the application; accurate machining is a must for proper mating of components.

The customer supplied the blueprint; Synthane Corporation did the rest—first producing the proper grade of material and then fabricating—accurately and without waste or delay.

The more than 33 grades of *Synthane* laminated plastics offer *you* a very wide range of properties in combination—physical, mechanical, electrical, and chemical. And good service and quality characterize *Synthane* fabrication. The coupon will bring you further information and technical data covering *Synthane* sheets, rods, tubes, and molded parts, and *Synthane* service.

SYNTHANE CORPORATION, 4 River Road, Oaks, Pa.

Please send me more information about *Synthane* laminated plastics and the *Synthane* fabrication service.

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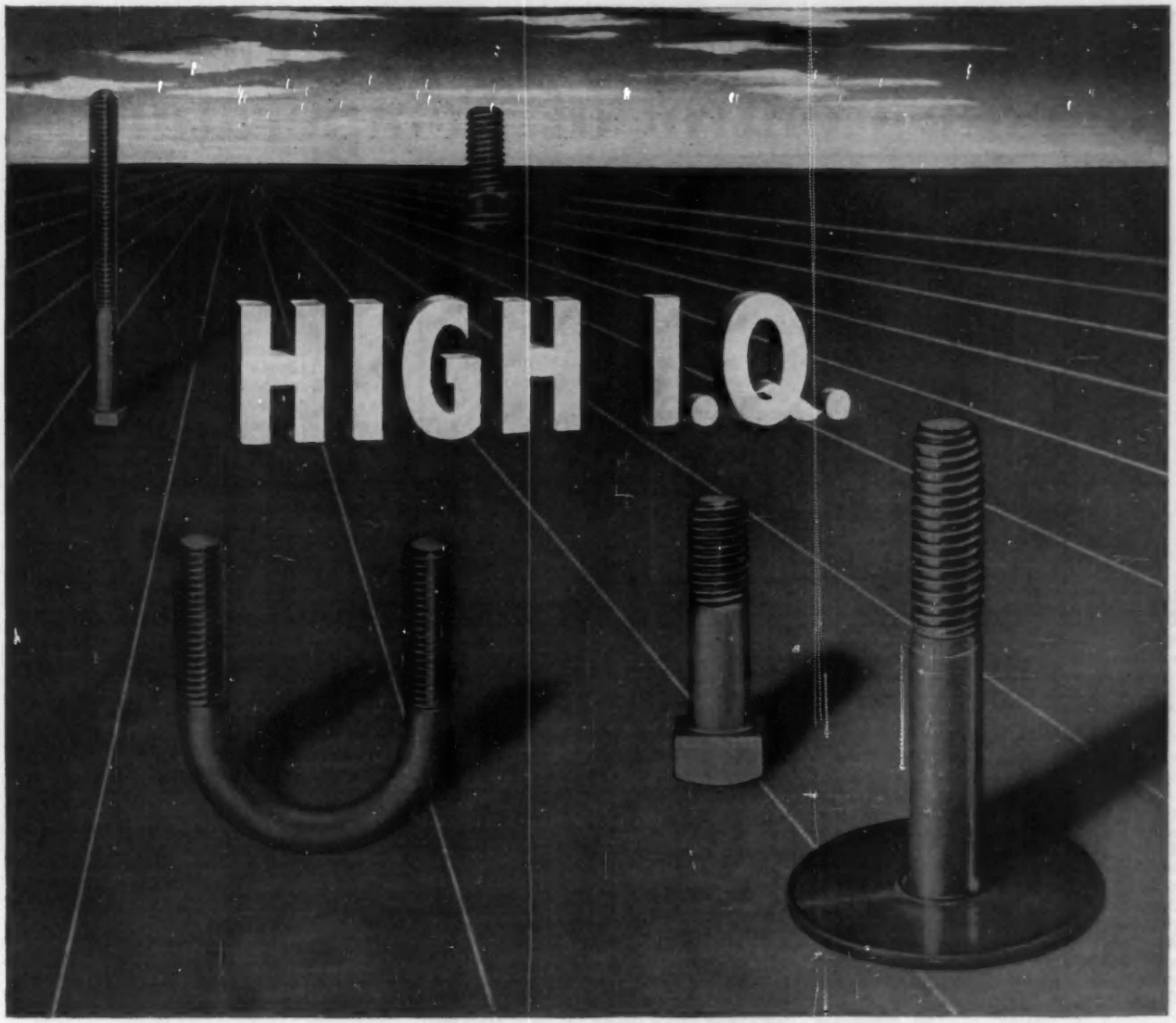

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Products of this high-strength, ductile alloy are resistant to stress-corrosion cracking . . . need no additional heat treatment.

Fine ductility and other *High Inner Qualities* of Bridgeport Silicon Bronze (Alloy 609) make it the logical choice for all types of cold-upset and roll-threaded screw products. Its finished tensile strength of about 90,000 psi assures rugged service under extreme conditions. Its superior corrosion resistance makes it ideal for outdoor applications.

Your nearest Bridgeport Sales Office will be glad to show you how Silicon Bronze and other Bridgeport *High I.Q.* alloys can add speed to your production, quality to your products, profit to your sales.

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Vapor Pressure Bellows Devices for Remote Control of Temperature

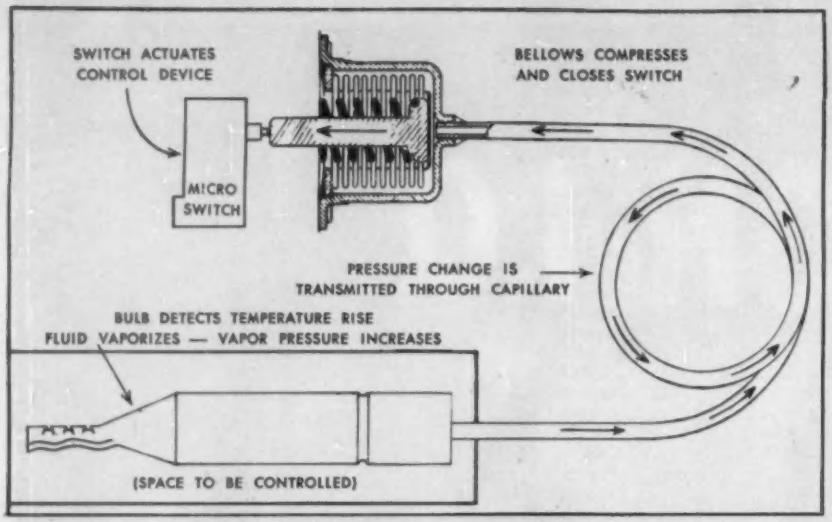

SWITCH ACTUATES CONTROL DEVICE
BELLOWS COMPRESSES AND CLOSES SWITCH
MICRO SWITCH
PRESSURE CHANGE IS TRANSMITTED THROUGH CAPILLARY
BULB DETECTS TEMPERATURE RISE
FLUID VAPORIZES — VAPOR PRESSURE INCREASES
(SPACE TO BE CONTROLLED)

Figure 1. Vapor pressure bellows assemblies provide remote temperature control over a temperature range from about −40F to a maximum of 500F, depending on the vapor pressure of the filling medium at the maximum temperature encountered. They offer the advantage of high sensitivity and relatively long bellows stroke. This principle may be applied using increase or decrease of the vapor pressure to transmit the force to actuate a control mechanism.

ADVANTAGES OF VAPOR PRESSURE CONTROLS

Vapor pressure bellows assemblies offer a number of advantages in temperature control applications. They are highly sensitive and provide very close temperature control. They are positive-acting, simple in operation and easy to install. They can be made "fail-safe" to protect the equipment to which they are applied. When spring loaded, vapor pressure assemblies can be adjusted within very close limits. Bellows stroke is relatively long, making it easy to actuate switches or valves without elaborate linkage. They can be used for temperatures as low as −40F or as high as 500F and not affected by ambient temperatures outside of the chamber to be controlled. As a result, vapor pressure bellows assemblies are widely used as temperature controls for refrigerators, ovens, appliances, hot water storage tanks, processing equipment, wax pots, acid baths and numerous specialized industrial applications.

Proved in use. Vapor pressure bellows systems have long been used as temperature controls. Hence, a large body of performance and design data has been accumulated. This data assures accurate prediction of performance of a vapor pressure assembly, given the conditions under which the system will operate. And, since the design considerations are well known, it is usually simple to design a vapor pressure bellows assembly that will meet service requirements satisfactorily. The Clifford Manufacturing Company has a broad range of standard thermostatic assemblies engineered for quality, economy and reliable operation. These can be furnished to meet a wide variety of temperature control applications or readily adapted in design to meet special requirements. Important savings can be achieved by utilizing a standard design. A sketch showing controlling factors and dimensions for your application will enable Clifford to advise you how a standard design will meet your requirements.

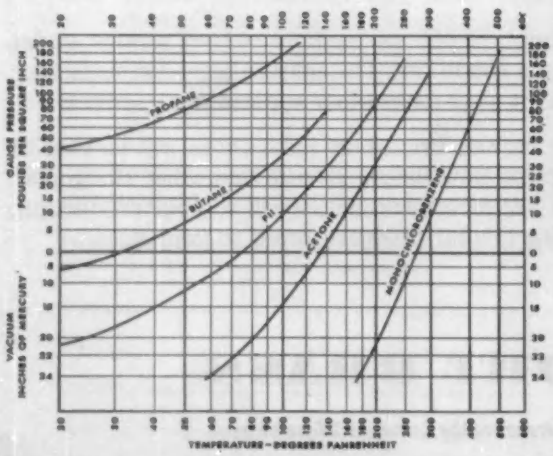


Figure 2. Vapor pressure-temperature curves for a few of the more common fluids used in vapor pressure bellows assemblies.

Operating principle (Fig. 1). When a confined liquid is heated, a vapor pressure is generated in the space above it. Vapor pressure as a function of temperature varies according to definite laws and so may be predicted accurately (see curves, Fig. 2).

Vapor pressure increases in an exponential curve. Butane, for example, from 30F to 40F changes pressure only 3 psi, but from 90F to 100F changes 9 psi. Therefore, a switch that operates with a .010 movement would have ⅓ the *temperature* differential at the higher end of the curve than a control operating at the low end of the curve.

The thermal fluid is stored in a temperature sensing bulb which is placed in the space to be controlled. The bulb is connected to a bellows cup assembly by a capillary tube. As the temperature of the bulb rises, vapor pressure in the bulb increases and is transmitted through the capillary to the cup. The force is exerted against the outside of the bellows, compressing it and moving the attached rod to actuate a switch or valve. A spring is usually incorporated as an adjusting means to provide an accurate setting of control temperature.

DESIGN CONSIDERATIONS

In the design of vapor-pressure systems, several factors must be considered: temperature range to be controlled, required sensitivity and the ambient temperature limits encountered. These requirements must be met by the right combination of bulb and bellows design and the thermal "fill" of the system.

Different combinations of factors are required if the controlled temperature is below, above, or *both* below *and* above the ambient temperature at the bellows.

Controls — bulb temperature lower than bellows. A control designed to operate at zero F, for example, must be charged with a thermal liquid having an active vapor pressure at that point, although the boiling point may be either above or below zero F. Methyl chloride (see Fig. 2) would be a logical filling medium for this application; it has a boiling point just under minus 10F and a vapor pressure of 3 to 4 psig at zero F. When used in refrigeration equipment, it functions satisfactorily, but since it has a vapor pressure of 150 psi at 120F, it would produce excessive pressure when subjected to high temperatures such as during shipment or storage of the unit. To design the assembly to withstand the overpressure would unnecessarily reduce the sensitivity of the control.

This is easily avoided in Clifford units through a calculated limited filling of the system. A volume of volatile liquid is selected so that it will be completely

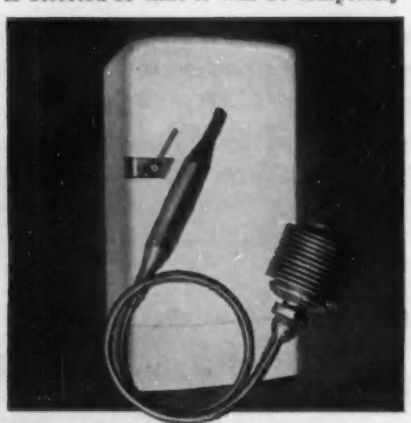


Figure 3. Clifford vapor pressure bellows assemblies are widely used in refrigerators. They provide positive action for the close temperature control essential to modern refrigeration.

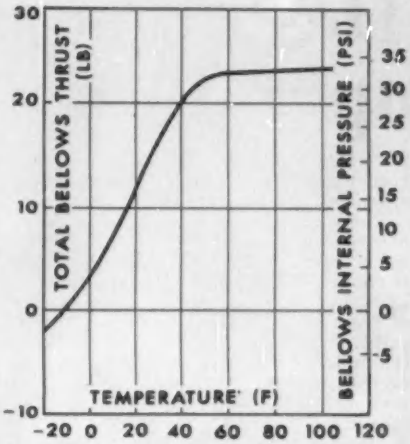


Figure 4. Temperature vs. thrust curve for a 1⅛" bellows with limited fill of methyl chloride. Full vaporization is complete about 50F. Only negligible gaseous expansion occurs above that point.

vaporized at a temperature just above the maximum desired control temperature. Beyond that point, only gaseous expansion takes place. Figure 3 shows the limited fill curve for a typical filling medium used in refrigerator temperature controls. Standard Clifford vapor pressure assemblies already engineered are obtainable for control of temperatures as low as −40F.

Ambient temperature has no significant effect on low temperature controls, because the volatile liquid is wholly contained in the bulb, which is usually quite small and located in the chamber to be controlled.

The pressure throughout the entire thermostatic assembly is always governed by the bulb temperature.

Controls—bulb temperature higher than bellows. For controls designed to operate at temperatures higher than the ambient temperature at the bellows, the assembly is almost completely filled with liquid. The vapor pressure is generated at the hottest point (the bulb) and transmitted to the bellows cup by the hydraulic action of the filling medium. The bulb is designed to trap the vapor within it, so that only *liquid* is forced out of the bulb and into the capillary and bellows cup. Over-temperature protection can be provided by limiting bulb size. Controls of this type are unaffected by ambient temperature. *The vapor pressure in the system is always a function of bulb temperature.*

Universal service. For control of temperatures *both* below *and* above the ambient temperature at the bellows, universal systems can be designed that draw on the principles of operation of both the low and the high temperature types just described. The bellows cup, capillary and bulb assembly is charged with a definite, precisely measured volume of the thermal liquid. When the capillary and bellows cup are *completely filled* with the thermal liquid, there must still be enough liquid left in the bulb to generate the necessary vapor pressure.

When the bellows and capillary temperatures go above the operating temperatures at the bulb, the liquid in the bellows and capillary vaporizes, expands into the bulb and condenses. The bellows cup is thus filled with a superheated gas at the same pressure as the vapor pressure generated by the volatile liquid in the bulb. A transition point is reached when the temperature of the bellows and capillary just equals that of the bulb. As the temperature of the bellows and capillary drops *below* that of the bulb, the liquid in the bulb rapidly vaporizes and condenses in the bellows and capillary until they are completely filled. Bulb design provides for some liquid to remain in the bulb. Further temperature increases bring about an increase in vapor pressure which is transmitted hydraulically through the capillary to the bellows cup.

Under any of the above conditions the temperature at the bulb always controls the operation of the system. The universal type control satisfies requirements that can be filled by neither the low-temperature nor high-temperature vapor-pressure types alone.

Dual Fill - Universal service can be obtained by a "dual fill" system. The unit is filled with controlled amounts of two insoluble liquids. Temperature changes are sensed by one liquid and the resulting vapor pressure changes are transmitted hydraulically through the second liquid to the bellows cup. This type of unit can be designed to have the "knock off" characteristics of the limited-fill unit (see Fig. 3).

"Fail-Safe" Design. If a liquid is chosen with a boiling point *above* the control point, the system operates under vacuum up through the control point. Vacuum should usually be limited to about 15 inches of mercury. Vacuum operation provides a "fail safe" feature in such applications as automobile thermostats. In the event that leakage occurs in the bellows or elsewhere in a closed system, the thermostat locks "open" and coolant continues to flow through the system. When controlling a heating medium, the control locks "closed" to shut off the source of the supply of heat.

Thrust. In vapor pressure assemblies, the thrust of the bellows at any temperature is definitely fixed by the vapor pressure of the filling medium and cannot be changed. Similarly, thrust differential between any two temperatures is fixed by the filling medium. Therefore, in the mechanical design of switch or valve mechanisms, friction should be minimized and maintained at a constant value.

Adjustment is commonly achieved by means of a spring and adjusting screw arrangement. The spring can control the operating temperature, the operating differential and the range over which the control temperature can be adjusted. The adjusting spring mechanism must be interrelated with the bellows cup assembly to achieve the desired operating characteristics.

Barometric compensation. For systems requiring extreme accuracy, it is sometimes desirable to compensate for barometric changes. Such correction is provided simply and accurately by a Clifford differential pressure unit (see Fig. 6). The vapor pressure is transmitted to the outside surface of the large bellows. The other side of the bellows is evacuated. The barometric changes then act on the areas of the smaller bellows, producing a null effect.

Clifford Manufacturing Company will consult with you regarding a thermostatic assembly that will meet your requirements. If you have an immediate problem, send a sketch showing controlling factors of your application and we will recommend a suitable control.

Clifford Manufacturing Company, 139 Grove Street, Waltham 54, Mass., *Division of Standard Thomson Corporation.*

Sales offices in New York, Detroit, Chicago, Los Angeles, Waltham, Mass.

7-5-14

Figure 5. Temperature regulators for water heating or cooling tanks, steam cookers, acid baths, glue heaters, bottle washers, tempering baths and other heating specialties used Clifford vapor pressure bellows assemblies as actuating elements.

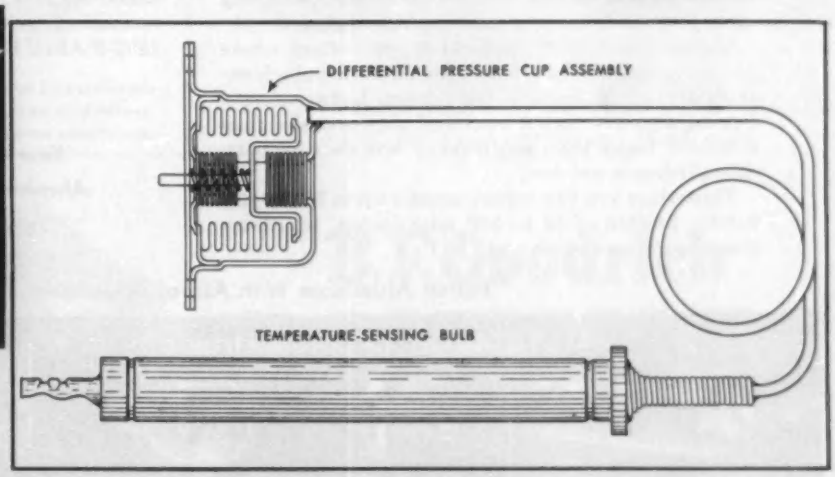
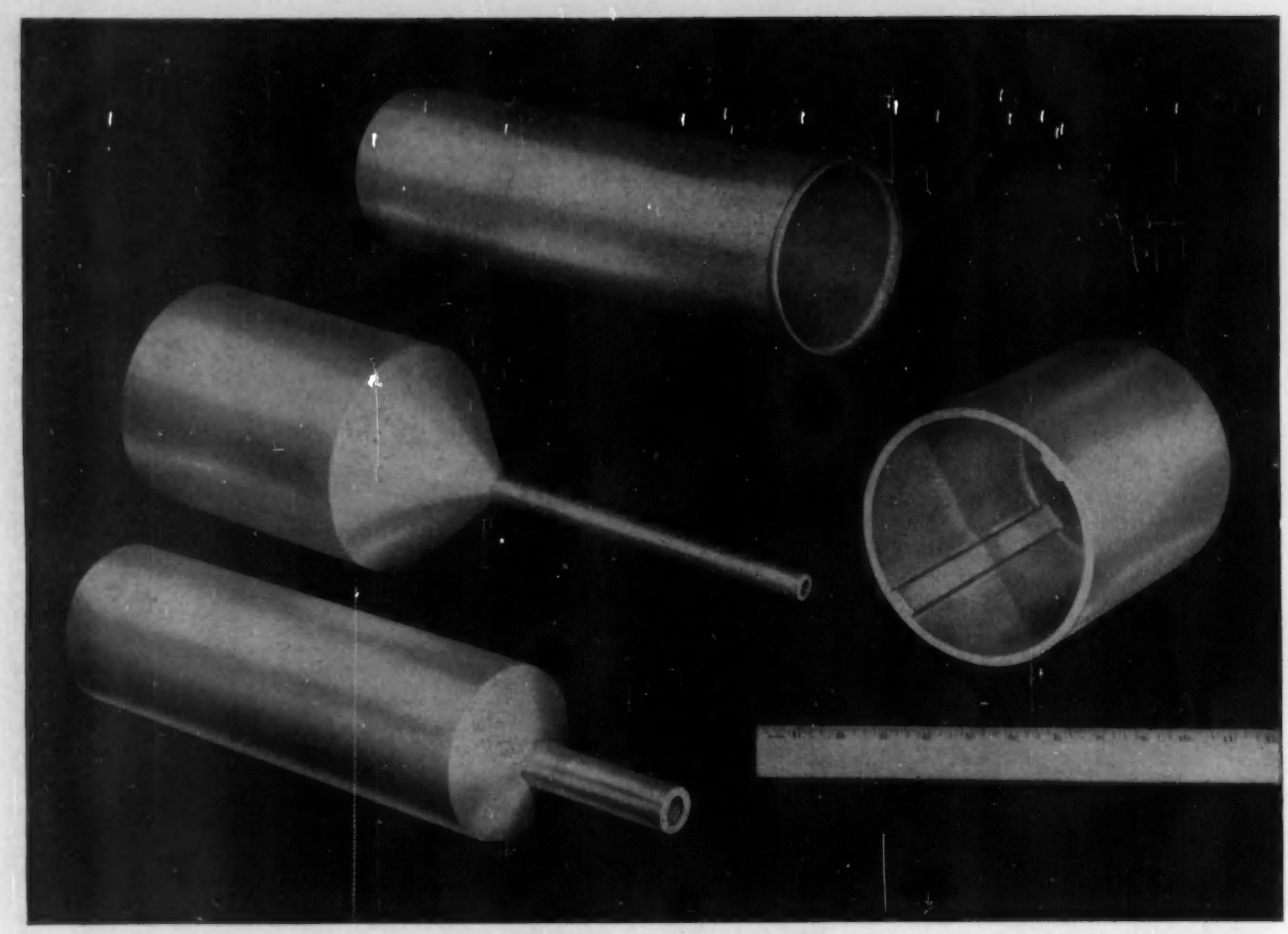


Figure 6. Vapor pressure bellows assembly with automatic barometric compensation.



SEE WHAT'S HAPPENED TO IMPACT EXTRUSIONS; ALCOA CAN MAKE THEM BIGGER AND STRONGER

(and with more complex design details than ever before)

People who think of aluminum impact extrusions only in terms of tooth-paste tubes are in for a shock these days. Hydraulic cylinders for jet aircraft are Alcoa Impacts. Complete electric motor housings are Alcoa Impacts. Parts as long as 18 inches, parts weighing up to 10 pounds are now made as Alcoa Impacts.

In the thousands of production applications where Alcoa Impacts are practical, they offer special advantages over other forms of fabrication. Lighter than a forging, stronger than a machined part, sounder than a casting, faster than weldment . . . and part for part, Alcoa Impacts cost less.

These days you can expect tensiles up to 75,000 psi, surface finishes of 40 to 250 microinches, length-to-diameter ratios as high as 12 to 1.

Where can you use Alcoa Impacts? Your local Alcoa sales engineer represents Alcoa's complete impact extruding facilities, and will be happy to help you investigate the many cost-saving design possibilities which Alcoa Impacts offer. For complete design information, write Aluminum Company of America, 1992-F Alcoa Bldg., Mellon Square, Pittsburgh 19, Pa.

Your Guide to Aluminum Value

ALCOA ALUMINUM

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Fasten Aluminum With Alcoa® Aluminum Fasteners

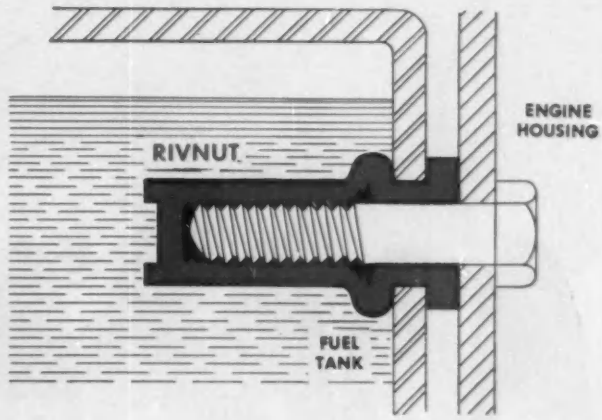
Alcoa Makes Impact Extrusions to Your Specifications

B. F. Goodrich Rivnut makes nut plate and shock-proof seal in one operation

BRIGGS & STRATTON CORP. wanted to speed the assembly and streamline the appearance of a new gasoline engine without extra cost. The conventional method of attaching fuel tanks required a combination of rivets, straps, braces, nuts and bolts. Now, by using three B. F. Goodrich Rivnuts, they do the same job quicker, neater and actually at lower cost.

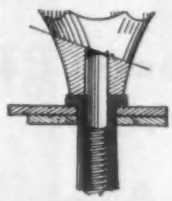
One man installs the Rivnuts in the gas tank wall in seconds. They provide, firm accurate nut plates that can't be loosened by shocks or vibration. At least six threads are clean for bolt attachment to the engine housing. At the same time, special closed ends make a 100% gasoline-tight seal.

B. F. Goodrich Rivnuts are solving hundreds of fastening problems. They can probably solve yours. Write for more information or engineering help to: The B. F. Goodrich Company, Dept. PE-75, Akron, Ohio.

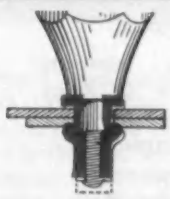


Rivnuts provide at least 6 clean threads in one simple operation!

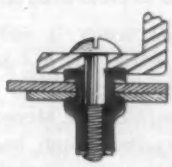
1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



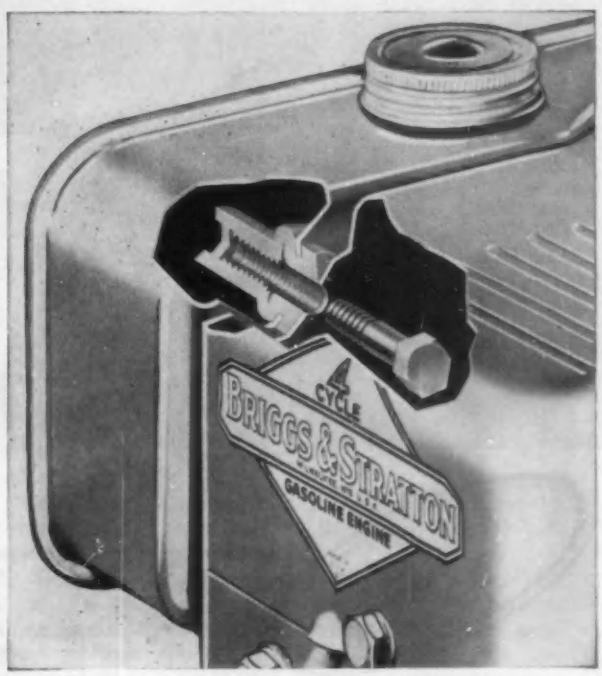
2 Rivnut is inserted—head firmly against work—tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.



4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.



Cutaway view of tank showing how Rivnuts make 100% gasoline-tight seal.

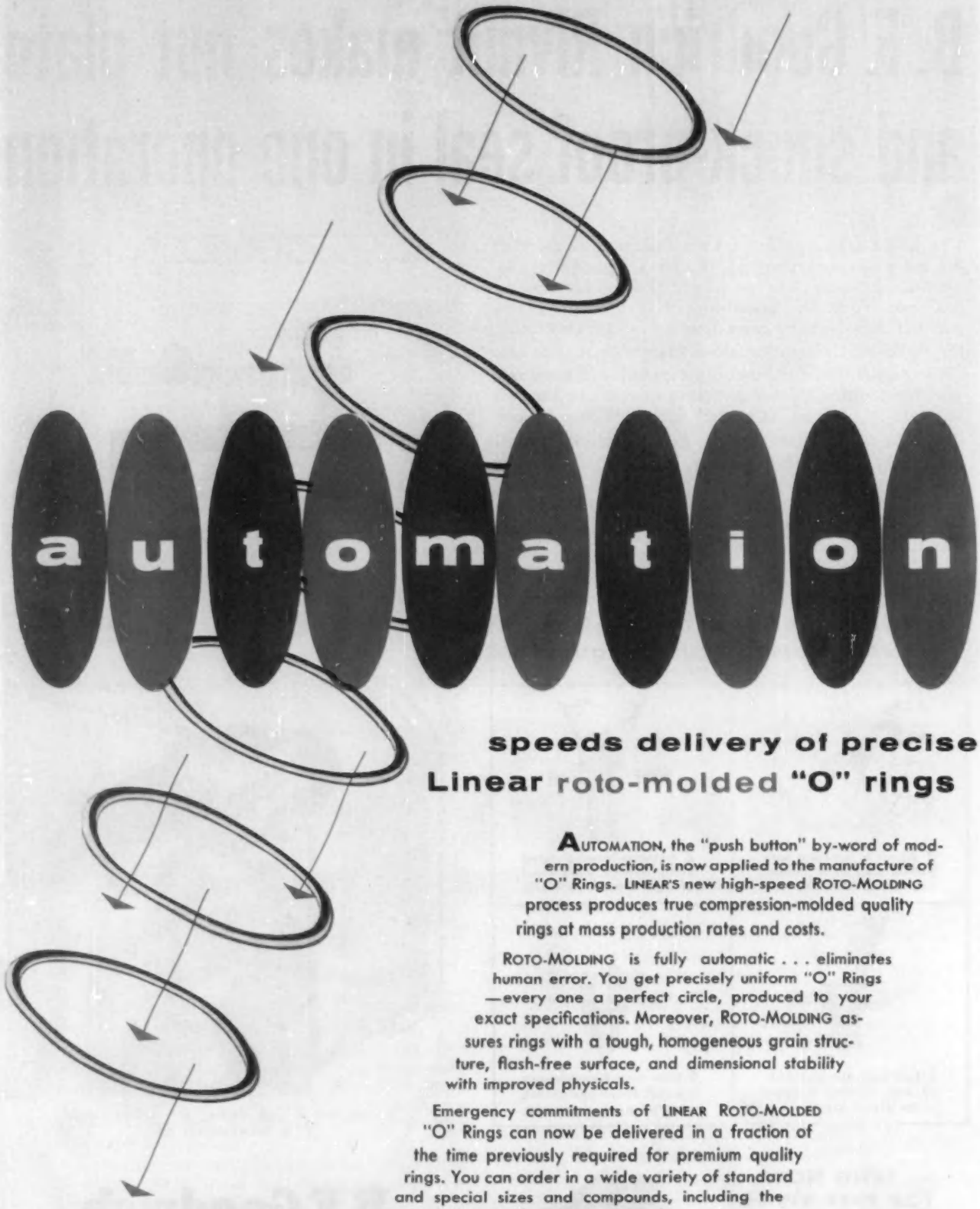
SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: The B. F. Goodrich Company, Department PE-75, Akron, Ohio.

B.F.Goodrich

RIVNUTS

The only one-piece blind rivet with threads



speeds delivery of precise Linear roto-molded "O" rings

AUTOMATION, the "push button" by-word of modern production, is now applied to the manufacture of "O" Rings. LINEAR'S new high-speed ROTO-MOLDING process produces true compression-molded quality rings at mass production rates and costs.

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LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

50-ton crane becomes 85-ton crane

with no increase in size

United States Steel's Edgar Thomson Works in Braddock, Pennsylvania, needed new and heftier crane equipment to handle larger ladles. One requirement was four new crane trolleys which were to operate on the same bridges, if possible, and in exactly the same clearances as before.

The trolleys had to be stronger but no larger than before; so ordinary steel wouldn't do. Needed, was a steel of *exceptional strength* which could be *welded easily*. Lots of alloy steels could have met the strength requirements; but USS "T-1" Steel was the *only* steel that could supply not only the required strength, but good weldability as well.

"T-1" Steel plate—in ¾" and 1" thicknesses—was used in box girders and lateral stiffener plates of the trolleys. This change increased the crane capacity from 50 to 85 tons with no increase in size.

The structure was welded with AWS E12015 electrodes. It was as easy as welding carbon steel. No stress relief was needed. And the welds developed the full yield strength of the steel: 90,000 psi. minimum.

Remember this story when you must weld very high strength parts—parts that must operate at temperatures as high as 900°F. or as low as 40°F. below zero, parts that must withstand tremendous impact abuse, abrasion or tensile stress. Then consider USS "T-1" Constructional Alloy Steel. For full particulars write: United States Steel, Room 4775, Pittsburgh 30, Pa.

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USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

UNITED STATES STEEL

There is no Substitute for SEALMASTER *Quality!*

Today's product designer is well aware of the importance of quality in the components used in each piece of machinery he engineers.

SEALMASTER Ball Bearing Units assure maximum performance and their exclusive combination of features provide a decided competitive advantage for any machinery manufacturer. Four features you will find in no other bearing unit except SEALMASTER are shown at left and explained briefly below. These are features to insure greater performance for the products you build. They are features you will want to learn more about. Write for full information:

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(2) Ball Retainer eliminates ball wear, traps grease and prevents churning.

(3) Locking Pin & Perimeter Dimple prevents rotation of outer bearing race and assures positive lubrication.

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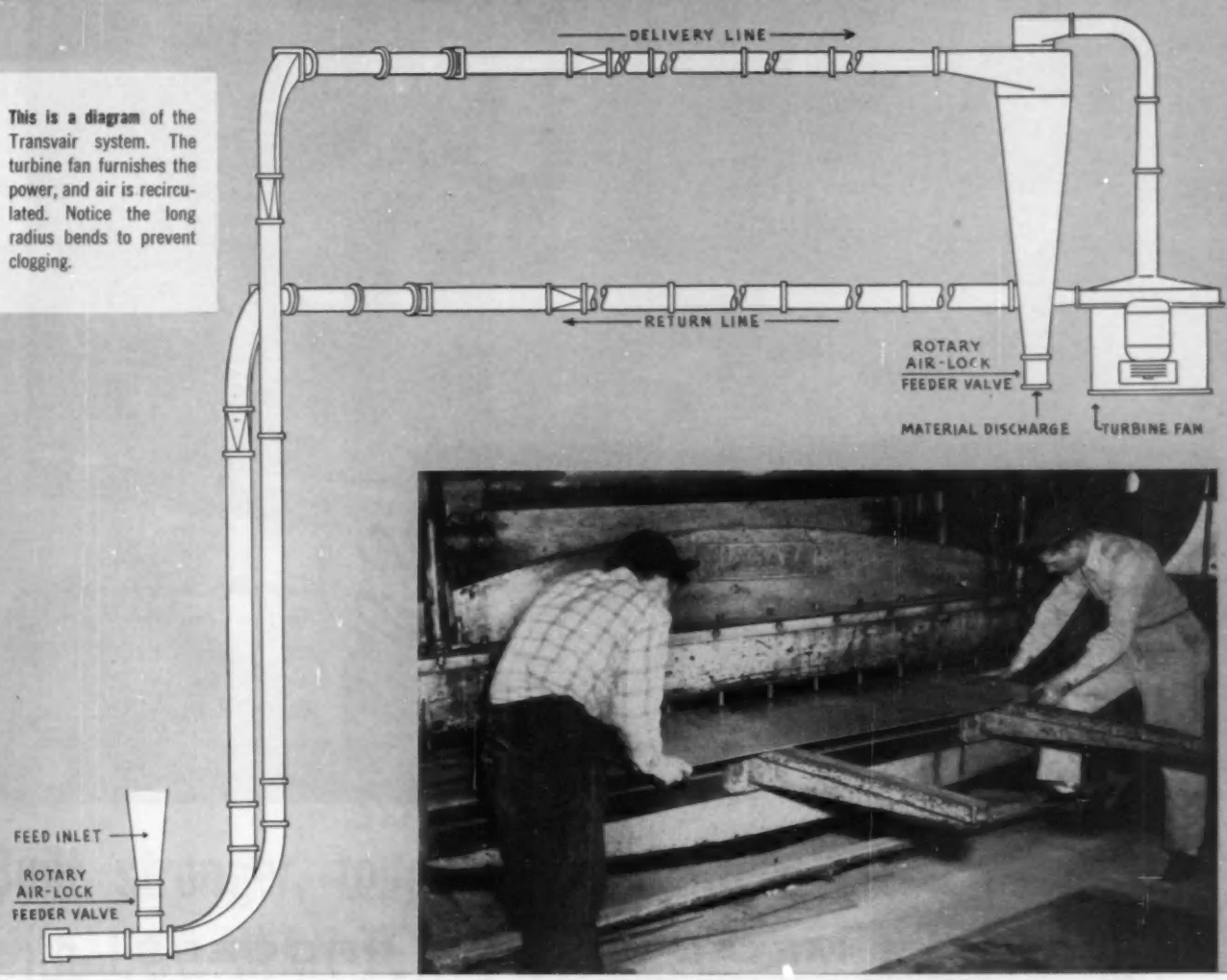
BALL BEARING UNITS

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 9 RIDGEWAY AVENUE, AURORA, ILLINOIS

How Stainless Steel prevents contamination in pneumatic transfer system

This is a diagram of the Transvair system. The turbine fan furnishes the power, and air is recirculated. Notice the long radius bends to prevent clogging.



Stainless Steel presents no fabricating problems at Young Machinery Company. This standard shear, for example, is used to cut both ¼" carbon steel and 10-gauge Stainless Steel.

Young Machinery Company makes a unique line of air conveyors that transfer dry, free-flowing materials through tubing. Energy is furnished by a turbine fan, and the entire system is sealed so that hazardous and toxic substances can be handled with safety.

Since contamination is a problem, the systems are frequently made from Stainless Steel. The first time that Young used this metal was in 1949, but now it accounts for 50% of their total production.

These systems are frequently used to move corrosive solids in the chemical industry — a natural use for Stainless Steel. Then, too, foodstuffs are often handled; and the dense, easy-to-clean surface of Stainless Steel is unmatched for this service.

There have been no production difficulties. Identical equipment is used for fabrication of Stainless Steel or carbon steel. In fact, it was not necessary to buy new equipment or even modify the older machinery when Stainless Steel was used.

No other metal combines the easy fabrication, corrosion resistance, high strength and cleanliness of Stainless Steel. If you plan to use this durable metal, remember that United States Steel has the nation's largest assortment of Stainless Steel shapes, sizes, types and finishes.

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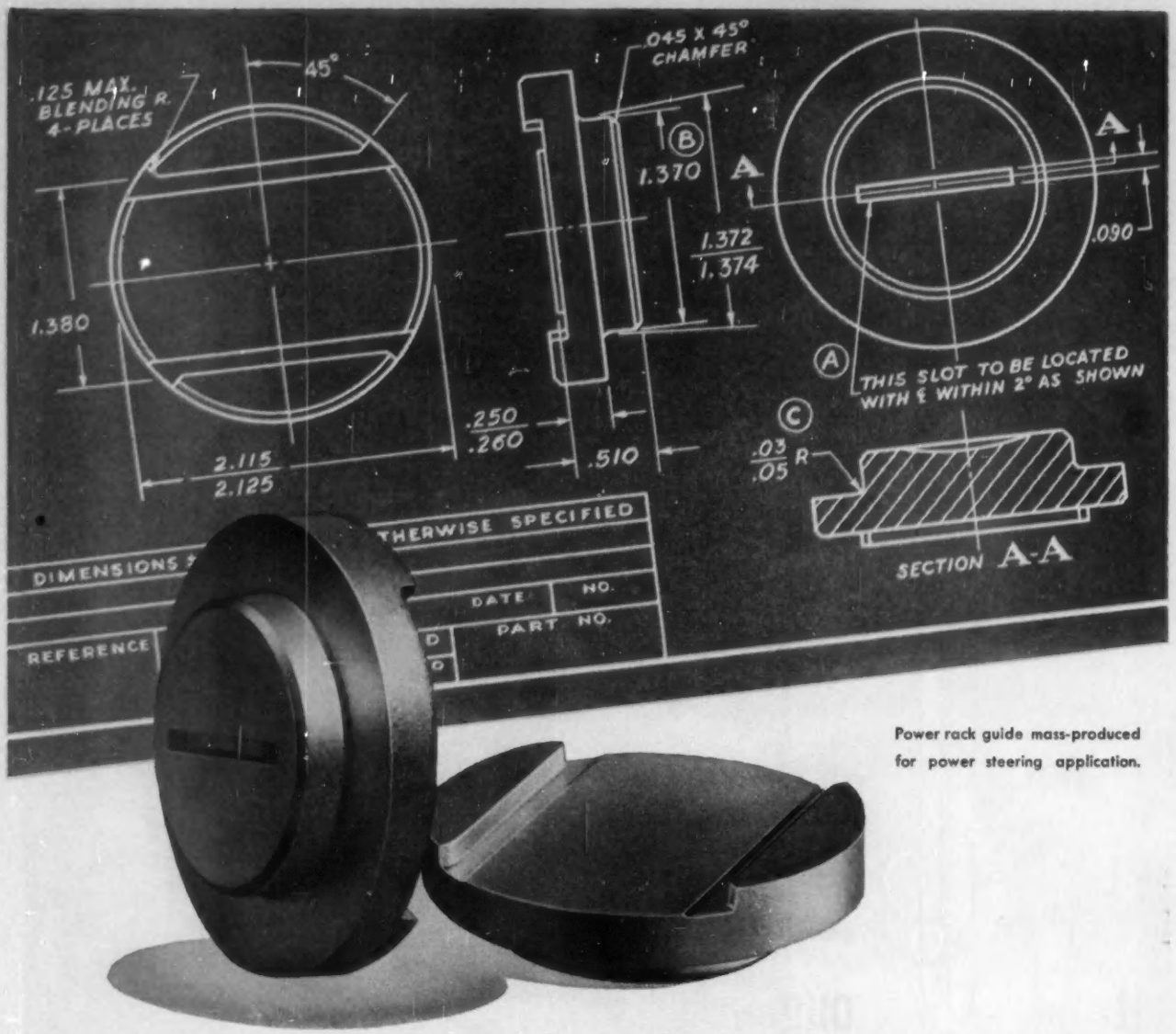
USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS • PIPE • TUBES • WIRE • SPECIAL SECTIONS

UNITED STATES STEEL



Power rack guide mass-produced for power steering application.

MORAINE METAL POWDER PROCESS MAKES COMPLEX PARTS - AT A SAVINGS

If made by conventional casting and machining methods, this part, which serves many of us every day, would cost more. Made by the Moraine metal powder process, however, the part is mass-produced quickly and economically—to precision standards.

Moraine makes many different parts of complex design from metal powder . . . parts with a quality and uniformity that make them highly desirable for a multitude of applications.

Many industries are using Moraine's experience in powder metallurgy to reduce the cost and improve the performance of many and varied products. Possibly, Moraine may be of service to you, too.

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DIVISION OF GENERAL MOTORS, DAYTON, OHIO

METAL POWDER PARTS

Built stronger, tougher and lighter with USS MAN-TEN Steel

Photographs courtesy of HYSTER COMPANY, Portland, Oregon

Famous HYSTER Logging Arch handles more footage faster

In this "packaged" logging unit, consisting of a Hyster Arch Towing Winch and Caterpillar Diesel Tractor, the objective of the engineers was to produce equipment having the highest degree of mechanical efficiency, plus durability and speed of operation.

Because the key to profits is greater log production, which means that unnecessary breakdowns must be eliminated, extra margins of safety have been built into all parts subjected to stresses and wear.

By using USS MAN-TEN High Strength Steel in the arch boom, A-frame and tongue, it was possible to reduce weight of these important members by 10%, and yet to *increase* their strength-to-weight ratio over former construction.

The increased strength provided by MAN-TEN Steel gives the arch the ability to handle log loads of maximum size, and the reduced arch weight means greater mobility and maneuverability. Result: The operator can get into tight spots easier and pick up loads faster. Reduced weight also permits greater grade climbing ability in steeper terrain.

With USS High Strength Steels — USS MAN-TEN, USS COR-TEN and USS TRI-TEN—you can build extra strength and toughness into vital parts and ensure greater resistance to wear, fatigue, abrasion and impact.

NOW AVAILABLE . . . Our new "Design Manual for High Strength Steels" is ready for distribution. This excellent book contains comprehensive and practical information that you will find extremely useful in designing your product for greater economy and efficiency by the sound use of high strength steels.

For your free copy, write on your company letterhead giving your title or department, to United States Steel Corporation, Room 4777, 525 William Penn Place, Pittsburgh 30, Pa.

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USS MAN-TEN HIGH Strength STEEL

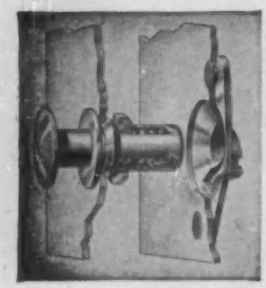
USS

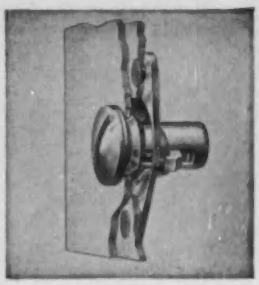
See "THE UNITED STATES STEEL HOUR"—Televised alternate weeks—Consult your newspaper for time and station.

5-1028

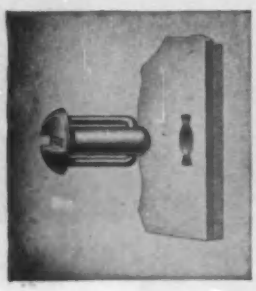
UNITED STATES STEEL

3 ways to save on assembly costs





QUICK-LOCK For fastening removable access doors and panels. Because of its ease of installation, QUICK-LOCK is ideal for assembling removable panels. A 90° turn locks it in place. Stud is self-ejecting when unlocked; visual inspection shows whether fastener is locked. Spring loading takes initial load; solid supports carry increased load. Available in a wide range of sizes.



SPRING-LOCK One-piece fastener for blind holes has load-carrying steel spring wire. Spring steel arms lock fastener securely, prevent loosening under vibration. SPRING-LOCK will work with varying panel thicknesses, locks with a twist of the wrist. SPRING-LOCK is now available in high-impact plastic. The molded design permits heads to be made in various shapes for refrigerator shelf supports, washer knobs, brackets. Available in a wide variety of shapes and sizes, and also in custom designs.

ROTO-LOCK Serrated, tapered cam is engaged by formed lug as fastener is locked. Cam action draws panels together tightly, insures locking even under conditions of misalignment. Opens easily for demounting. ROTO-LOCK carries heavy tension and shear loads; can be used for air and water-tight seals; recesses completely into panels. Solidly built without springs or delicate mechanical parts, unaffected by arctic temperatures or field service.

Simmons

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SPRING-LOCK
ROTO-LOCK
LINK-LOCK
DUAL-LOCK

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If you are interested in cutting your costs, turn to Simmons Fasteners—the fasteners with *uses unlimited*. Write for samples and catalogs today.

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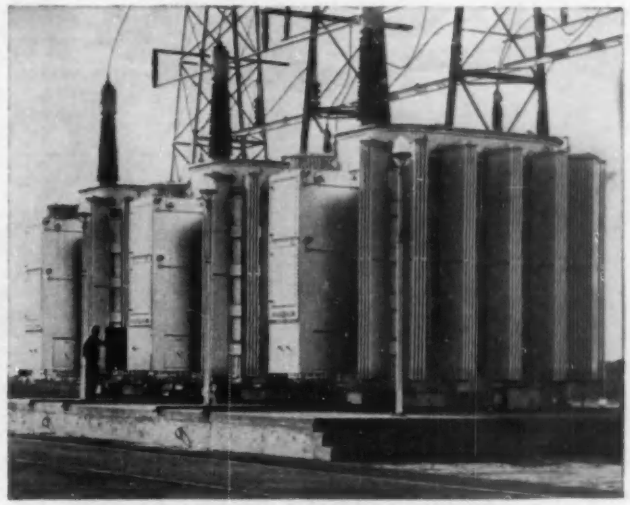
speaking of electricity, what is the best rubber for...

AN ARCTIC RADAR INSTALLATION?...



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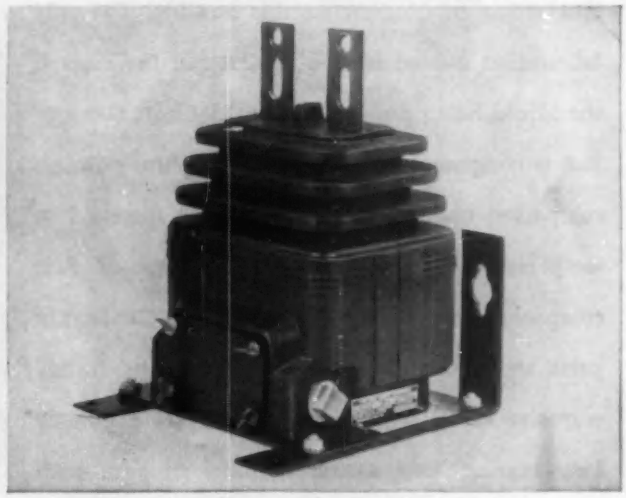
AN UNDERGROUND SERVICE CABLE?...



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Enjay Butyl is outstanding for all!

Enjay Butyl retains flexibility to allow radar screens to operate at sub-zero temperatures. Enjay Butyl's superior resistance to corona and ozone gives better performance with high-voltage cables. Enjay Butyl can withstand high internal heat without becoming brittle, making it ideal for use in underground service cables. And Enjay Butyl's excellent electrical properties and all-weather durability enable it to perform the dual function of insulator and casing for a transformer.

That's why the use of Enjay Butyl in the electrical industry is expanding. To find out how these and other advantages of Enjay Butyl can improve your product, contact the Enjay Company.

Our technical representatives and laboratories are at your service.

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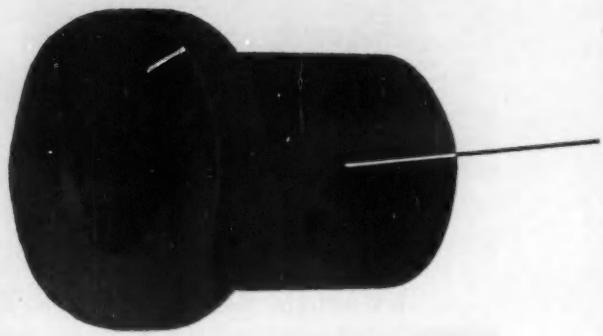
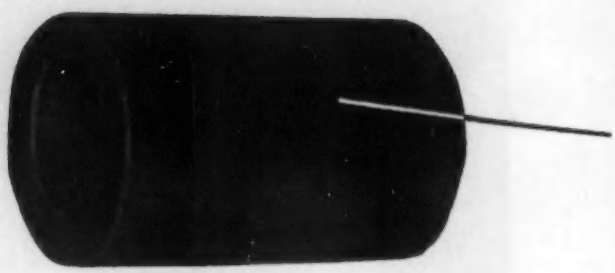
GRAPHITAR® BUSHINGS IN VIKING

(CARBON-GRAPHITE)





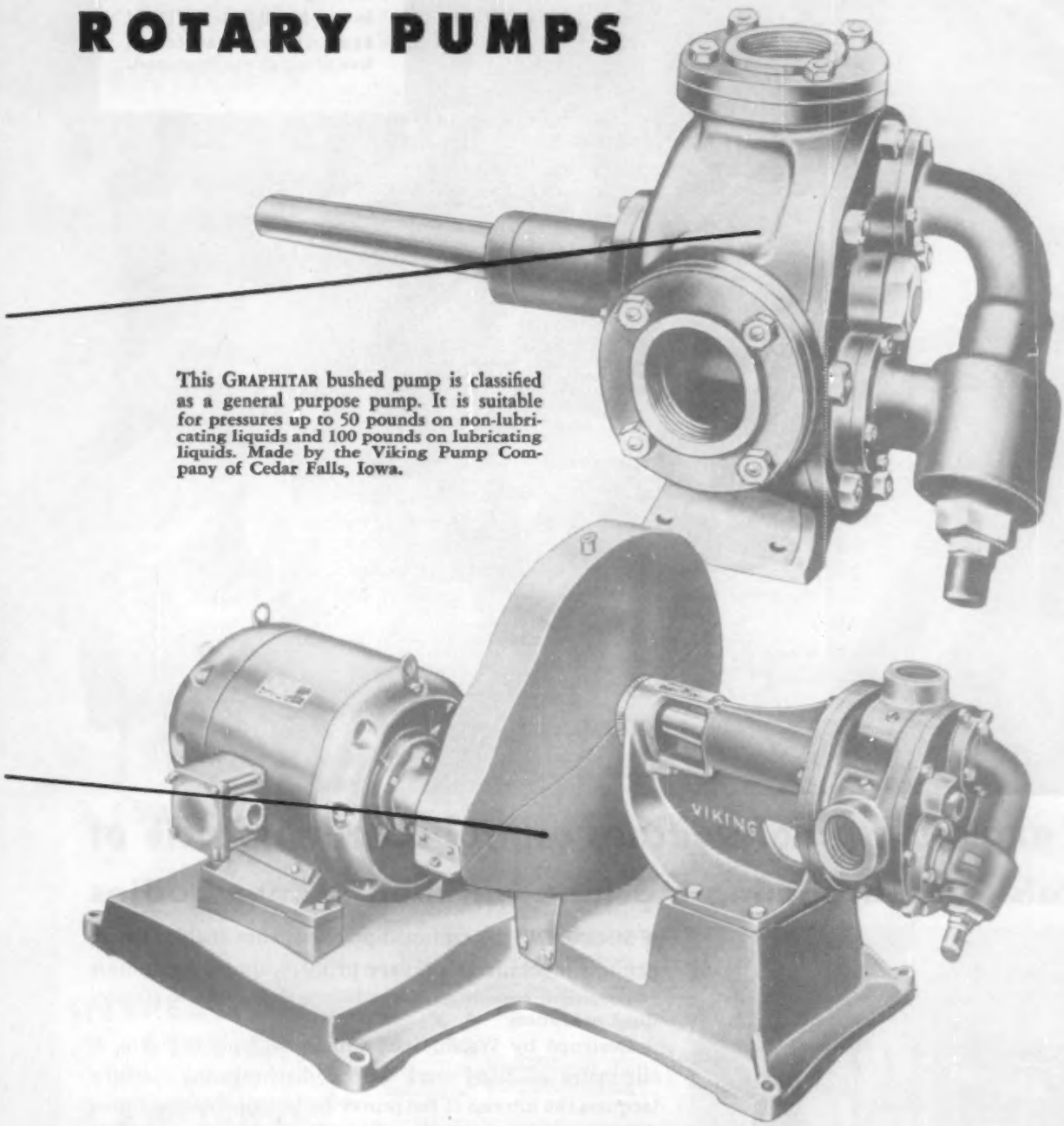
One of the features that accounts for the popularity of these two Viking rotary pumps is the fact that they require no outside lubrication of any kind. GRAPHITAR bushings make this possible. The only lubrication needed by the GRAPHITAR bushings is the liquid being pumped, (even LP-Gas). GRAPHITAR is compounded from carbon-graphite powders compacted under heavy pressure and furnaced at temperatures approaching 4500°F. Because of their composition and method of manufacture, GRAPHITAR parts are chemically inert (will withstand highly corrosive acids), will not warp and are extremely long-wearing. GRAPHITAR combines strength with lightness, and is virtually unaffected by high speeds or pressures or temperatures. It can be formed in relatively complex shapes and ground to tolerances as fine as .0005". In short, a really versatile engineering material. Write for our illustrated catalog.

OUR 101ST YEAR

THE UNITED STATES

NEED NO LUBRICATION

ROTARY PUMPS



This GRAPHITAR bushed pump is classified as a general purpose pump. It is suitable for pressures up to 50 pounds on non-lubricating liquids and 100 pounds on lubricating liquids. Made by the Viking Pump Company of Cedar Falls, Iowa.

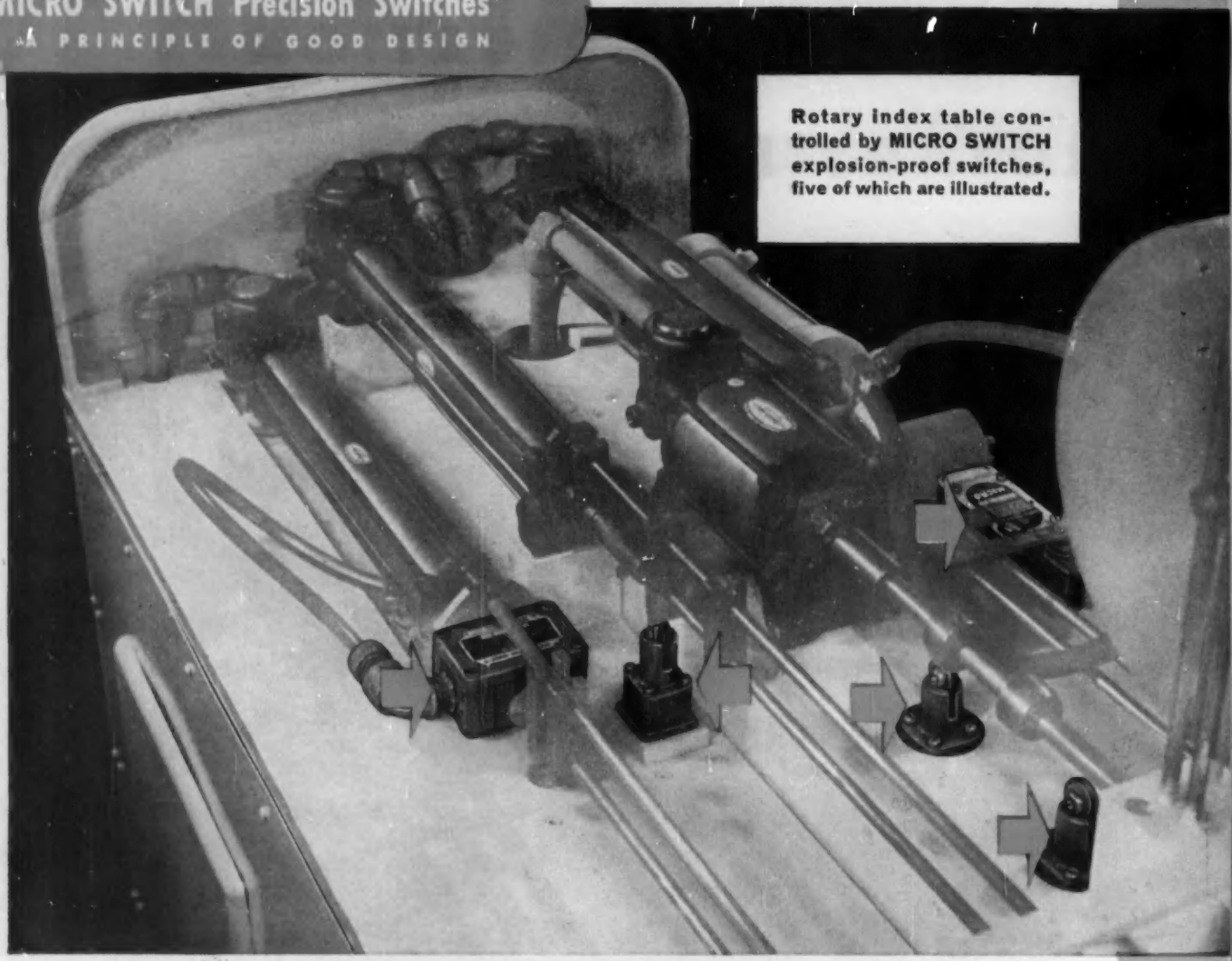
The unusual properties of GRAPHITAR suit it well for use as bearing and mechanical seal in this Viking heavy-duty pump capable of handling 100 pounds pressure on non-lubricating liquids and 200 pounds on lubricating liquids.

205

GRAPHITE COMPANY

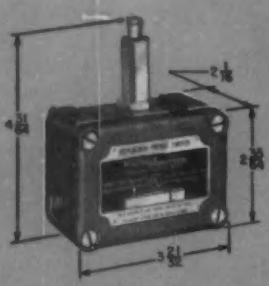
DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

MICRO SWITCH Precision Switches
A PRINCIPLE OF GOOD DESIGN



Rotary index table controlled by MICRO SWITCH explosion-proof switches, five of which are illustrated.

9 explosion-proof switches control operation cycle of Walsh Diaphragming Machine for shell primer bodies



MICRO SWITCH Explosion-proof Switch with Plunger Actuator.

MICRO SWITCH Explosion-proof Heavy Duty Limit Switch with Roller Plunger Actuator.

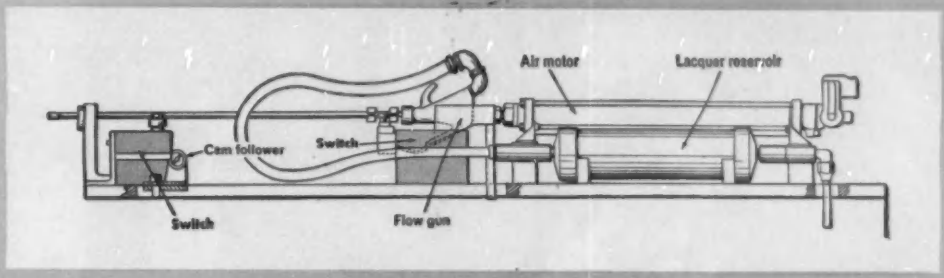
• MICRO SWITCH explosion-proof switches enable this ingenious machine to prepare primers, under hazardous atmospheric conditions, for artillery shells in one streamlined operation.

Designed by Walsh, Inc., Chicago engineering firm, it eliminates all hand work as the diaphragming machine lacquers the interior of the primer body; punches and forms diaphragms from a paper roll; seats diaphragms to proper depth and provides final inspection.

Here is a typical example of the important part played by MICRO SWITCH products in the development of automatic machinery to serve a wide range of industrial applications. Whatever your design problem, whatever your switch requirement, you will find MICRO SWITCH engineering experience a valuable ally. This cooperation will cost you nothing, can save you much.

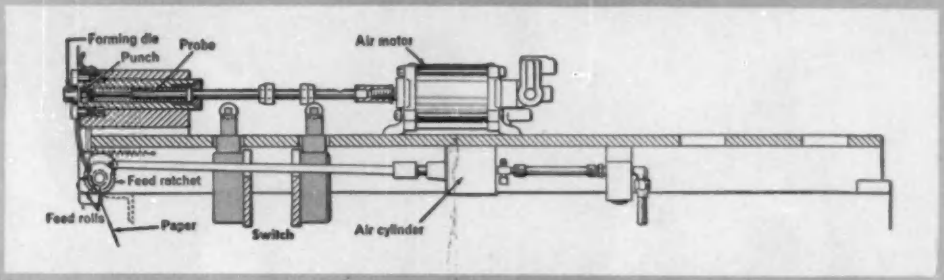
MICRO SWITCH *engineering help is as close as your telephone. Branches in 20 key cities.*

LACQUER STATION
2 SWITCHES



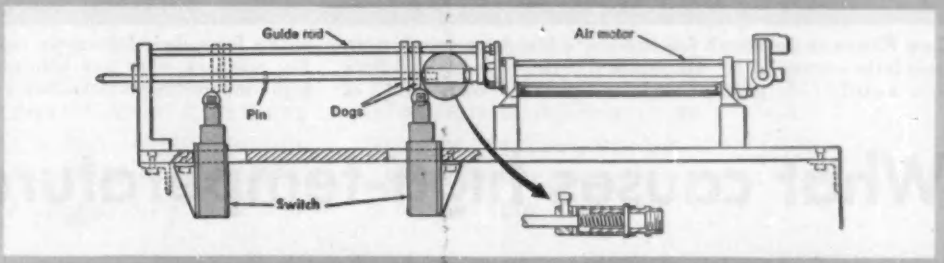
• As the nozzle approaches the surface that requires spraying, a fixed cam follower trips the control valve. Two MICRO SWITCH precision switches, horizontally mounted, control the depth of the nozzle in the tube and the pulsing of the fluid reservoir, and interlock.

INSERTION STATION
2 SWITCHES



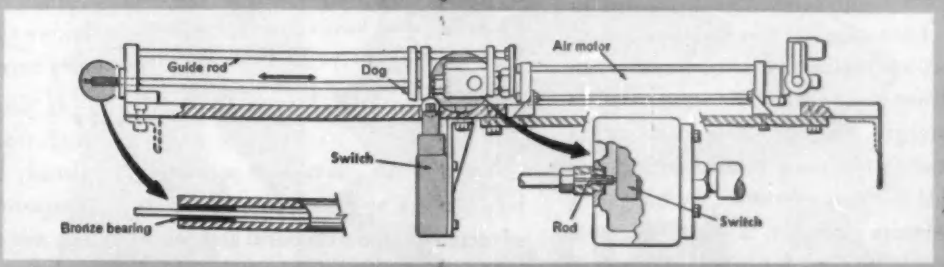
• Spring loaded punch cuts paper diaphragm before insertion probe makes contact. At the end of the cutting motion, probe continues forward and forms blank into cup shape. Final portion of the travel inserts diaphragm. The two MICRO SWITCH limit switches control the forward and back limits of travel.

SEATING STATION
2 SWITCHES



• Diaphragm is pushed to proper depth as determined by the position of the switch-actuating dogs. Fixed guide rod insures accurate alignment of dogs and switch contacts.

INSPECTION STATION
3 SWITCHES



• Depth is checked by means of switch actuating rod in hollow probe. If incorrectly seated, the MICRO SWITCH limit switch does not operate and dog operates return switch that also signals reject. This mechanism makes it impossible for empty tubes to be passed should paper supply become exhausted.

A complete line of snap-action and mercury switches

MICRO SWITCH provides a complete line of extremely reliable, small-size, high-capacity, snap-action precision switches and mercury switches. Available in a wide variety of sizes, shapes, weights, actuators and electrical characteristics. For all types of electrical controls.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

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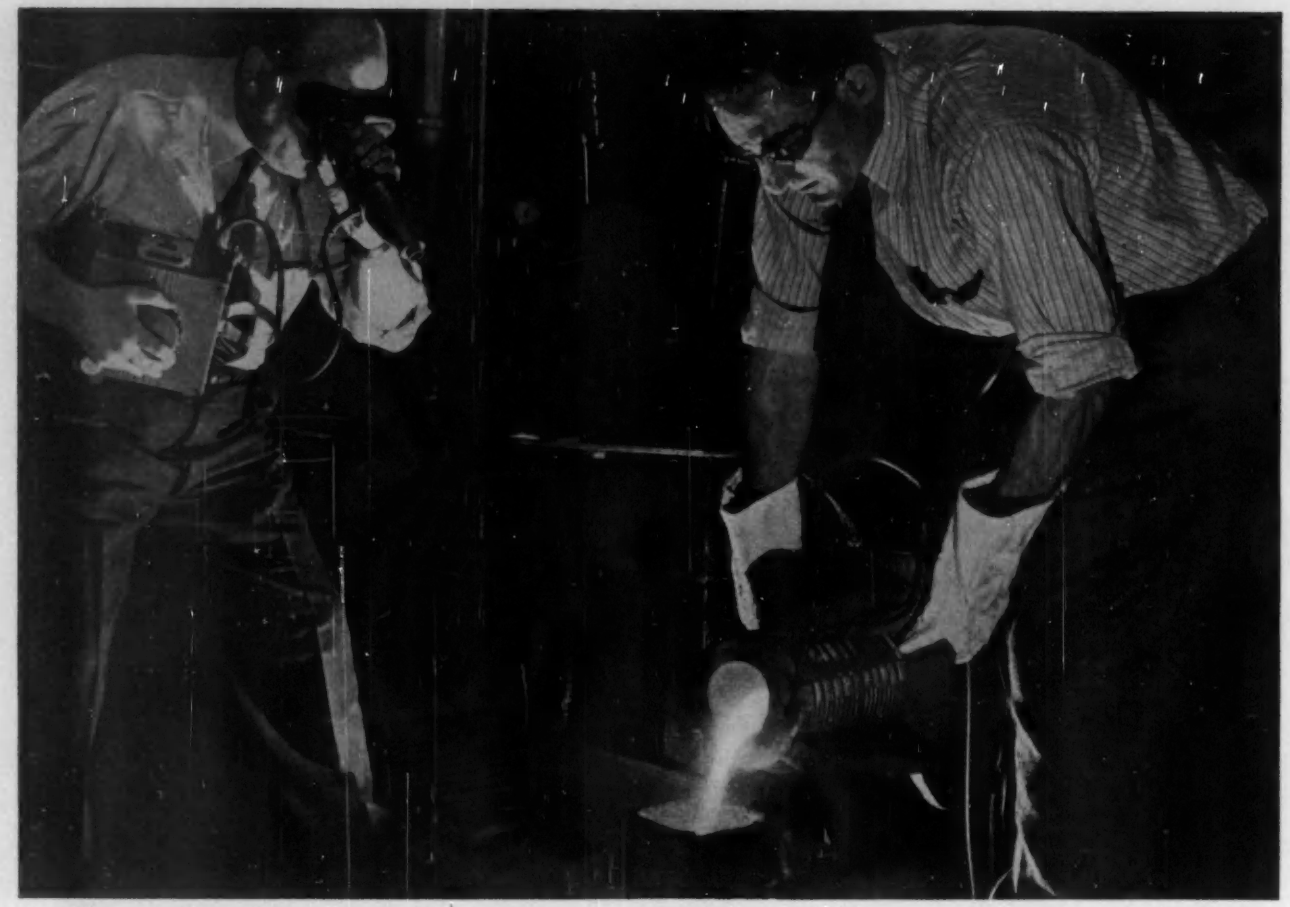
H HONEYWELL



One Phase of the search for answers to high-temperature questions is the continuing development and testing of new alloys. Here Inco metallurgists pour a carefully controlled composition of metals from their laboratory radio-frequency induction furnace. The resulting alloy may help to solve some of the unanswered high-temperature problems facing engineers today.

What causes high-temperature failure?

Strange reactions can take place when metals and alloys are exposed to high heat.

Even common soot and the air itself become destructive corrosives that can disintegrate a metal and waste away its strength. The more these reactions are studied the more evident it becomes that the damage caused by high temperature corrosion is one of the most serious reasons for metal failures.

Unless a metal or alloy can resist destruction by its corrosive environment under operating conditions, it makes little difference how high or low its mechanical properties may be.

No single metal or alloy can resist all these corrosive conditions. For 20 years Inco metallurgists have been experimenting with carefully controlled compositions of metals . . . searching for the answers to the problems posed by expanding temperature frontiers. From this work have come such strong, heat-resisting alloys as Inconel® and Inconel "X"®, Incoloy® and the Nimonic® Alloys.

Yet with the gas turbine seemingly held in check by the temperature limits of metals, with the chemical and petroleum industries moving from "red-hot" to "white-hot" process temperatures, and with the development of the rocket engine and nuclear power pushing ahead, you may be asking yourself, "Have metals reached their limit of practical service at today's operating temperatures?"

Inco metallurgists think not. Who knows what future research programs may reveal?

If you have a problem involving high temperatures, the solution may already be in the files of Inco's High Temperature Engineering Service. If not, our engineers will be glad to work with you to find it. The first step is to write for a High Temperature Work Sheet, our form that helps you outline your problem for study. After that it is up to us. There is no obligation on your part.

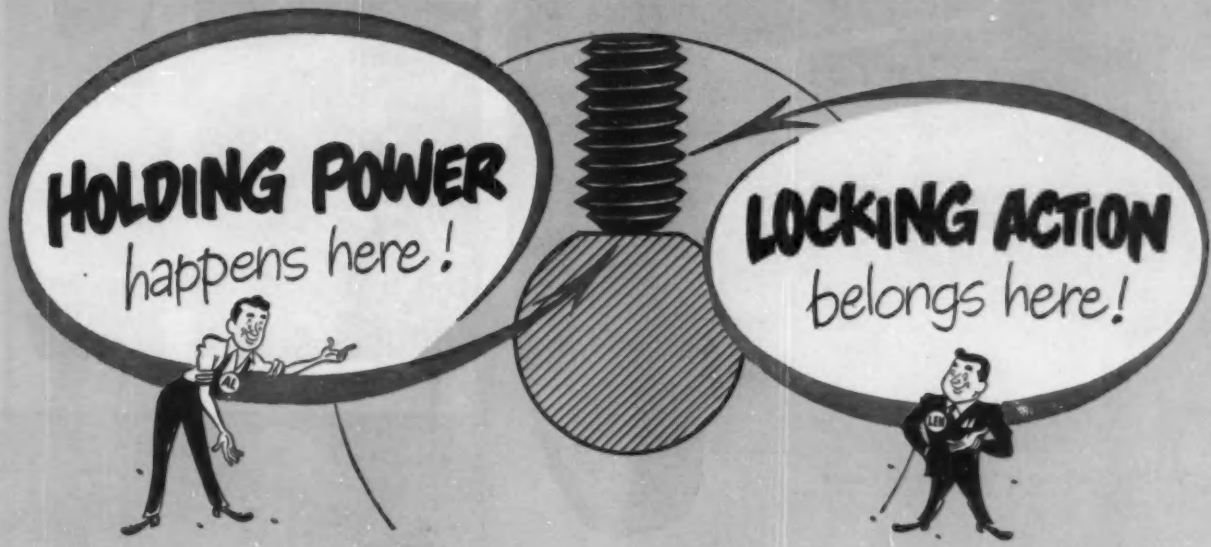
INCO TRADE MARK

NICKEL ALLOYS PERFORM BETTER LONGER

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street New York 5, N. Y.

SPECIFY ALLENPOINT SET SCREWS BECAUSE



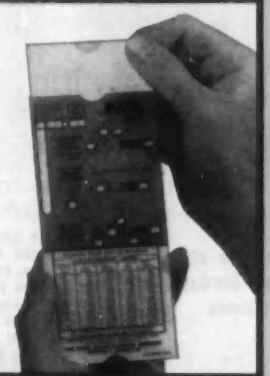
For maximum *holding power* against both rotation and sideway motion Allen developed the new *Allenpoint* — proved superior in exhaustive impartial tests (data on request).

Allen ○ screws do not weaken the holding power of the point with serrations in an attempt to make it perform a locking function too. High, uniform accuracy of fit, pitch diameter and perfect thread lead provide locking action the *right* way — from maximum thread contact. This locks the screw in place perfectly during use and *re-use* under extreme vibrating stress.

Your Allen Distributor's full stock of Allenoy and stainless socket screws puts an Allen warehouse right in your area. Allen-trained representatives plus Allen factory engineering bring a world of precision fastening experience as near as the phone on your desk.

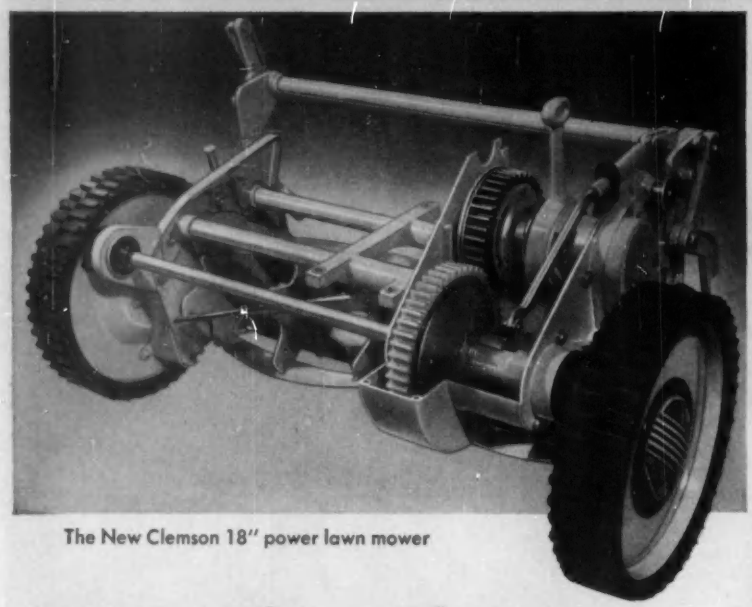
FREE —

New and improved pocket SCREW CALCULATOR. Write to Dept. G for it on your business letterhead.

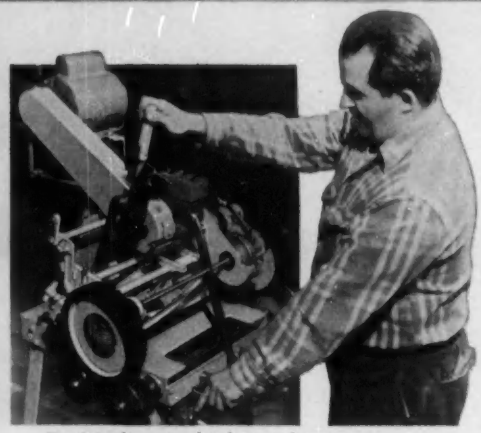


WARNING
Allen-Type screws aren't necessarily Allen-Made.
Get genuine "Pressur-Formed" Allen○Head screws in this black and silver box.

DIE CASTING REPORT



The New Clemson 18" power lawn mower

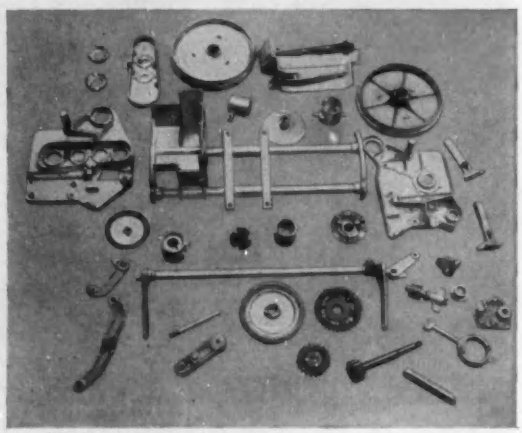


Testing die-cast clutches and cams

New Lightweight Power Lawn Mower---

Utilizes 34 die-castings to cut production costs, assembly time and integrate parts

Die-cast gears, worms



34 die-cast parts from 27 dies

No stranger to die-castings (having specified them successfully since the earliest 1937 model), Clemson Bros., of Middletown, N. Y., a leading lawn mower manufacturer, decided to go all out on their new power unit. Reason: Clemson found die-castings cut costs and could withstand functional shock, stress and strain. In addition, engineers had increased freedom in designing a more efficient, sales-appealing machine. Working closely with Precision die builders, they made maximum use of modern die-casting techniques to produce complicated steel inserts, worms, sleeves, gears, cam surfaces and achieve unusual contours. Majority of machining done by the die-caster simplified assembly of component parts, many of which were held to such close tolerances they could be used "as cast."

Die-cast steel inserts

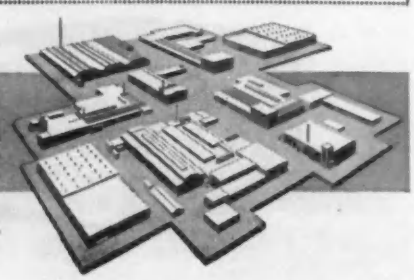
Cam surfaces cast in shells

Extensive Use of Functional Die-Castings Pays Dividends

If you are planning to design functional parts, why not look into the advantages of aluminum, magnesium or zinc die-castings. Precision's team of creative engineers will be glad to show you how this modern production process can help cut costs and supply unlimited number of identical parts, held to close tolerances. Write on your letterhead for a copy of "Die-Castings...Unlimited." Address: Precision Castings Co., Inc., 311 Walnut St., Fayetteville, N. Y.

PRECISION CASTINGS CO., INC.

World's largest independent producer: aluminum, magnesium and zinc die castings



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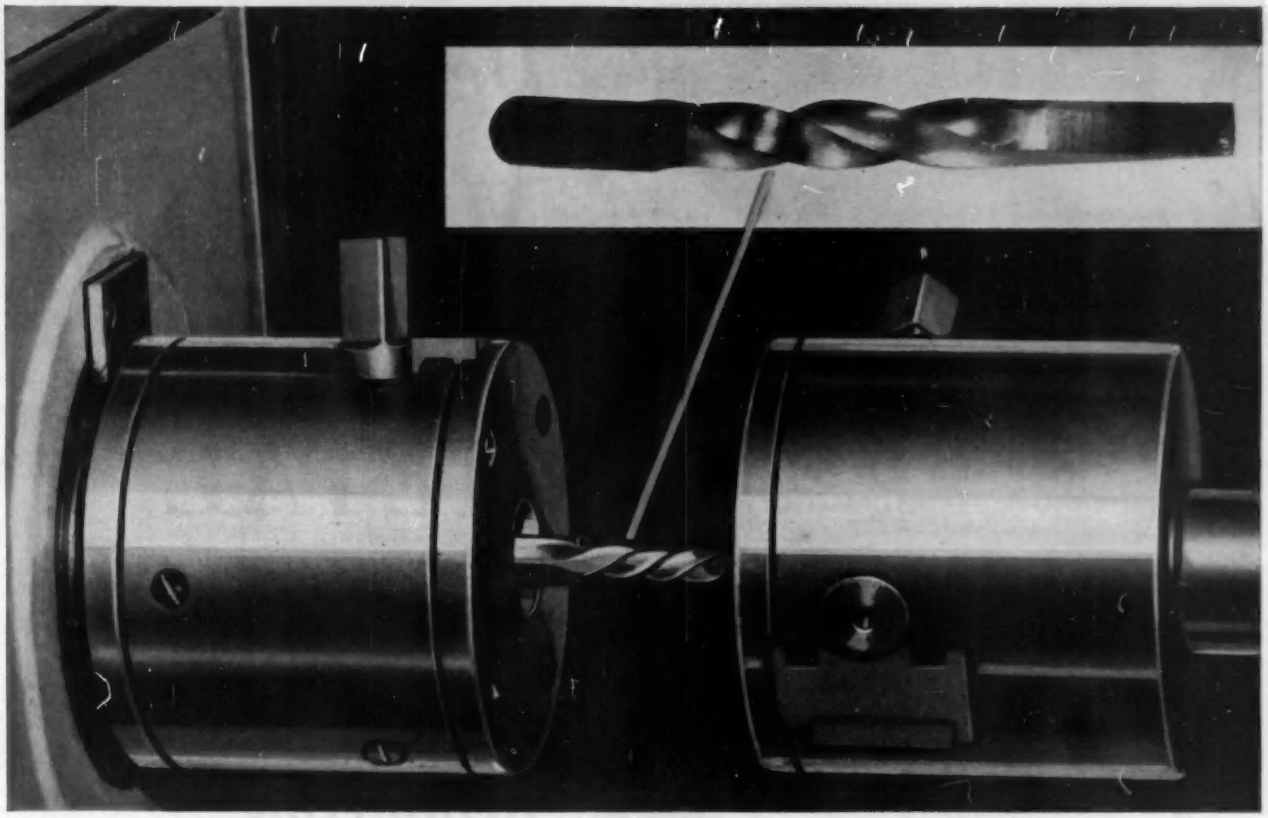
IN POWDER METALLURGY . . . IT'S AMPLEX



New STEEL OILITE'S unusual ductility is demonstrated in this photo of a typical torsion test. This revolutionary material was developed by Chrysler for applications requiring extreme ruggedness.

NEW Ductile STEEL OILITE® Opens Up New Uses for Powder Metals

STEEL OILITE is a new and revolutionary Chrysler developed die-pressed powder metal with ductility and strength in the range of low carbon steel (elongation values up to 15%; tensile strength from 35,000 to 120,000 PSI).

Makes considerable savings possible for countless new applications; one customer reported savings of 96%. Eliminates most machining operations.

STEEL OILITE may be hardened, machined and staked using conventional methods. Developed by Chrysler-Amplex engineers, STEEL OILITE has been production and field tested for over 18 months.

The engineering facilities of Amplex and Chrysler are unmatched in the powder metal industry. They are ready to help you. Call or write today for STEEL OILITE information. Ask for Bulletin STM-54.

CHRYSLER AMPLEX PRODUCTS

OILITE Bearings
Permanent Metal Filters
Finished Machine Parts
Friction Units

Write today for new STEEL OILITE Bulletin STM-54. It's yours for the asking.

OILITE — *Only Chrysler makes OILITE*

CHRYSLER CORPORATION • AMPLEX DIVISION

Dept. F-7 — Detroit 31, Michigan

★ *High Density* MALLORY 1000 METAL *always delivers uniform properties*

SPECIFIED PROPERTIES OF MALLORY 1000 METAL

	Average	Minimum
Density (parts up to 2500 grams)	16.96 gm/cc	16.71 gm/cc
Tensile strength (ultimate)	112,000 psi	94,000 psi
Modulus of rupture (simple beam, center loaded)	220,000 psi	180,000 psi
Elongation (% in 2")		2%

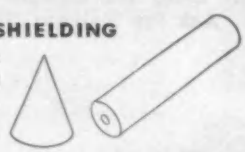
There is a difference in high density metals . . . especially in their uniformity. For the designer and the production man, the high standards of uniformity to which Mallory 1000 Metal is produced are the best guarantee of reliable performance in the finished product.

We invite you to compare the specifications for Mallory 1000 with any other high density material. These are not simply representative or "typical" properties. There's nothing vague about these figures. They are the characteristics on which you can depend in *every* part made from Mallory 1000 . . . and on which you can base accurate design calculations. This dependability is proving valuable in many applications for this unique material, including critical service in aircraft gyroscopes and counterbalances.

In addition to its high density and strength, Mallory 1000 offers excellent weathering qualities and ready machinability to high surface finish. Exclusive contour pressing techniques developed by Mallory produce intricate shapes to accurate tolerances. For complete information, write to Mallory for Technical Bulletin 6-7.

RADIOACTIVE SHIELDING

Up to 40% more efficient than lead, Mallory 1000 Metal is an excellent material for radioactive shielding.



In Canada made and sold by Johnson Matthey & Mallory, Ltd., 110 Industry Street, Toronto 15, Ontario

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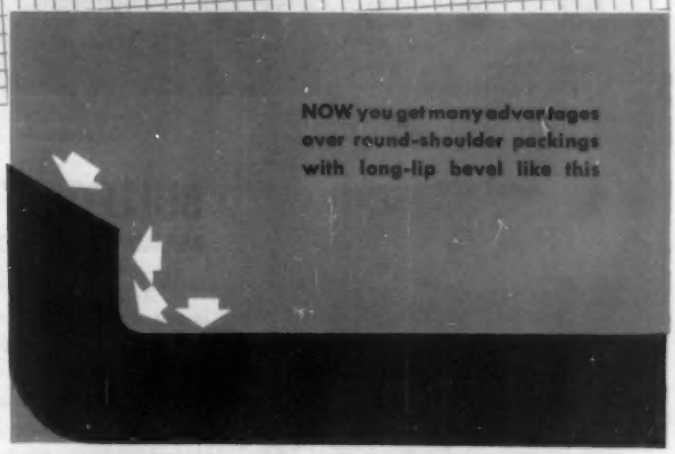
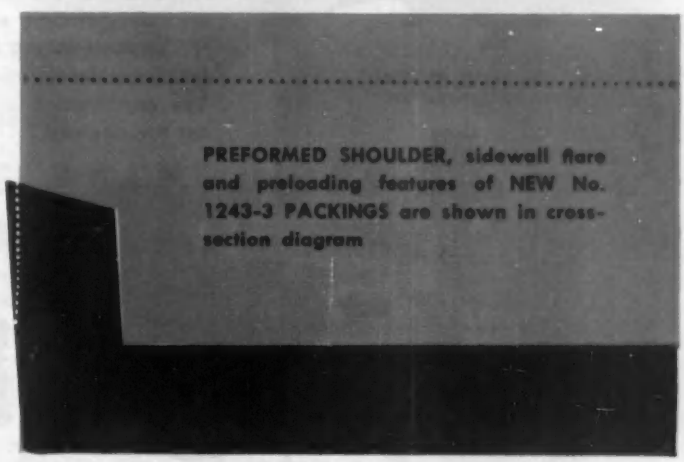
REVOLUTIONARY IDEA?

YES... NOW HOUGHTON'S NEW PACKING DESIGN IS PROVED BY PERFORMANCE



Here's what years of testing and actual performance records have established about the benefits of *Vim No. 1243-3 preformed, preloaded Packings:*

- 1. Leaks at low pressure are eliminated!
- 2. Packings won't rupture at top pressures!
- 3. Friction is substantially reduced!


PREFORMED SHOULDER, sidewall flare and preloading features of NEW No. 1243-3 PACKINGS are shown in cross-section diagram

The widening use of these unique cup packings has also served to upset the general belief that synthetic rubber could not be thoroughly impregnated in leather. Houghton engineers have demonstrated in No. 1243-3 that *the advantages of both can be combined for greater effectiveness!*

Ask the Houghton Man for more detailed information. Or write to Packing Research Department, E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

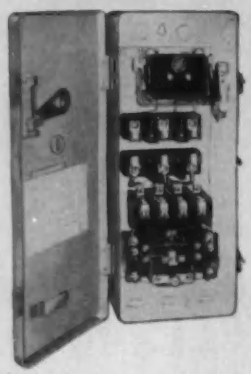
VIM NO. 1243-3 RUBBER IMPREGNATED LEATHER CUP PACKINGS

...a product of

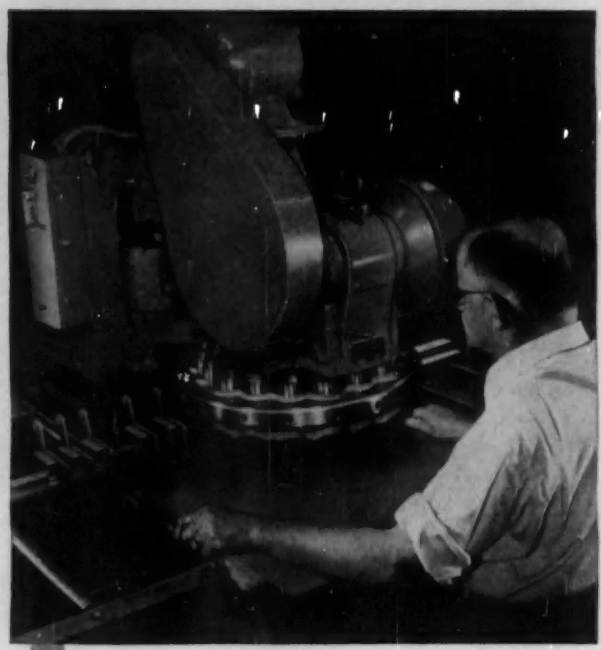
E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

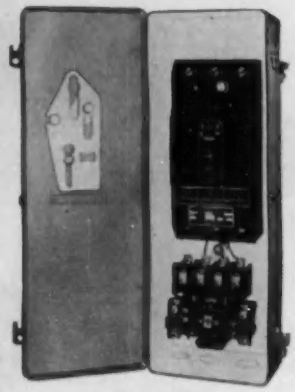
Ready to give you on-the-job service...



Bulletin 712 combination starter with manual, fused disconnect and solenoid starter in NEMA Type 1 general purpose enclosure



Weidemann turret punch press equipped with Allen-Bradley Bulletin 712 combination starter



Bulletin 713 combination starter with I-T-E circuit breaker and solenoid starter in NEMA Type 1 general purpose enclosure

BULLETIN 712-713 COMBINATION STARTERS

MAKE MORE COMPACT and SAFER CONTROL INSTALLATIONS

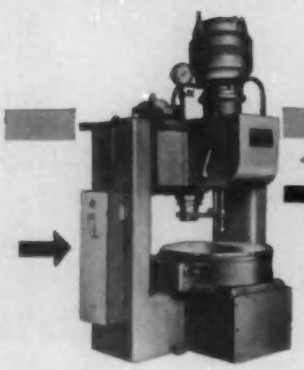
Many motorized machine installations call for a manual disconnect or circuit breaker ahead of the magnetic starter. In such cases, do not order the two units in separate enclosures . . . specify Allen-Bradley combination starters, which have both units in ONE enclosure.

The cost—taking installation time into consideration—is usually less. The combination starter is "safe" for the operator. Cabinet cannot be opened unless disconnect lever is in OFF position. Starter and fuses are then "dead."

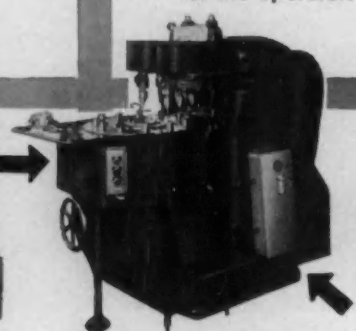
The magnetic starters in these combination starters are Allen-Bradley Bulletin 709 solenoid starters with double break, silver alloy contacts that need no maintenance. Thermal relays give continuously reliable overload protection.

Send for Bulletin 712-713.

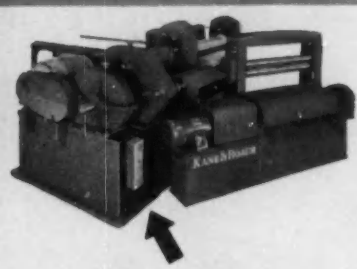
A-B comb. starter on CELAB 50 kw. selenium rectifier



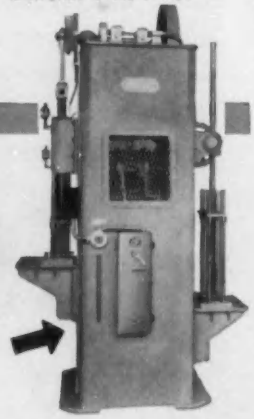
A-B combination starter on Loomis 100 ton hydraulic press



A-B comb. starter on Globe multiple tapping machine



A-B comb. starter on Kane & Roach slitting machine



A-B combination starter on Link spring fatigue tester

Allen-Bradley Co.
1329 S. First St.
Milwaukee 4, Wisconsin

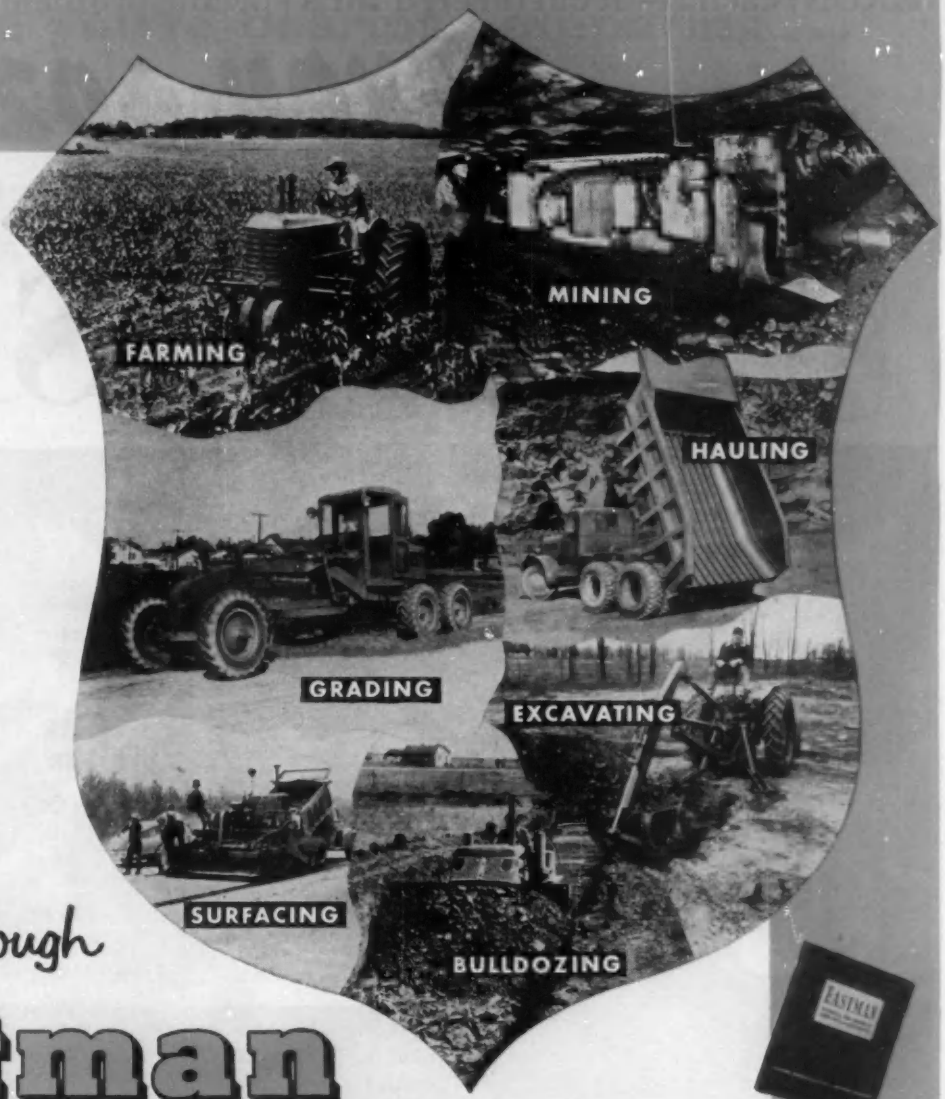
In Canada—
Allen-Bradley Canada Ltd.
Galt, Ont.

ALLEN-BRADLEY

SOLENOID MOTOR CONTROL

QUALITY

SAFEGUARDING INDUSTRY'S *Lifelines of Mobile Power*



MODERN INDUSTRY MOVES WITH HYDRAULIC POWER

delivered through

Eastman

HYDRAULIC HOSE ASSEMBLIES

EASTMAN — *first in the field* of Hydraulic Hose Assemblies—has had the privilege of *pioneering* in many original applications of hydraulic power — on equipment made by many of America's leading manufacturers — as shown in action in the industries, above.

Modern industry not only moves *hydraulically*, but with increased efficiency and economy—with improved production and performance . . . the kind of performance that improves your competitive position in your field.

If you have a power transmission problem, consult with Eastman Engineers. For improved performance due to many original exclusive Eastman designs . . . for quality of material and workmanship—always specify Eastman Hydraulic Hose Assemblies.

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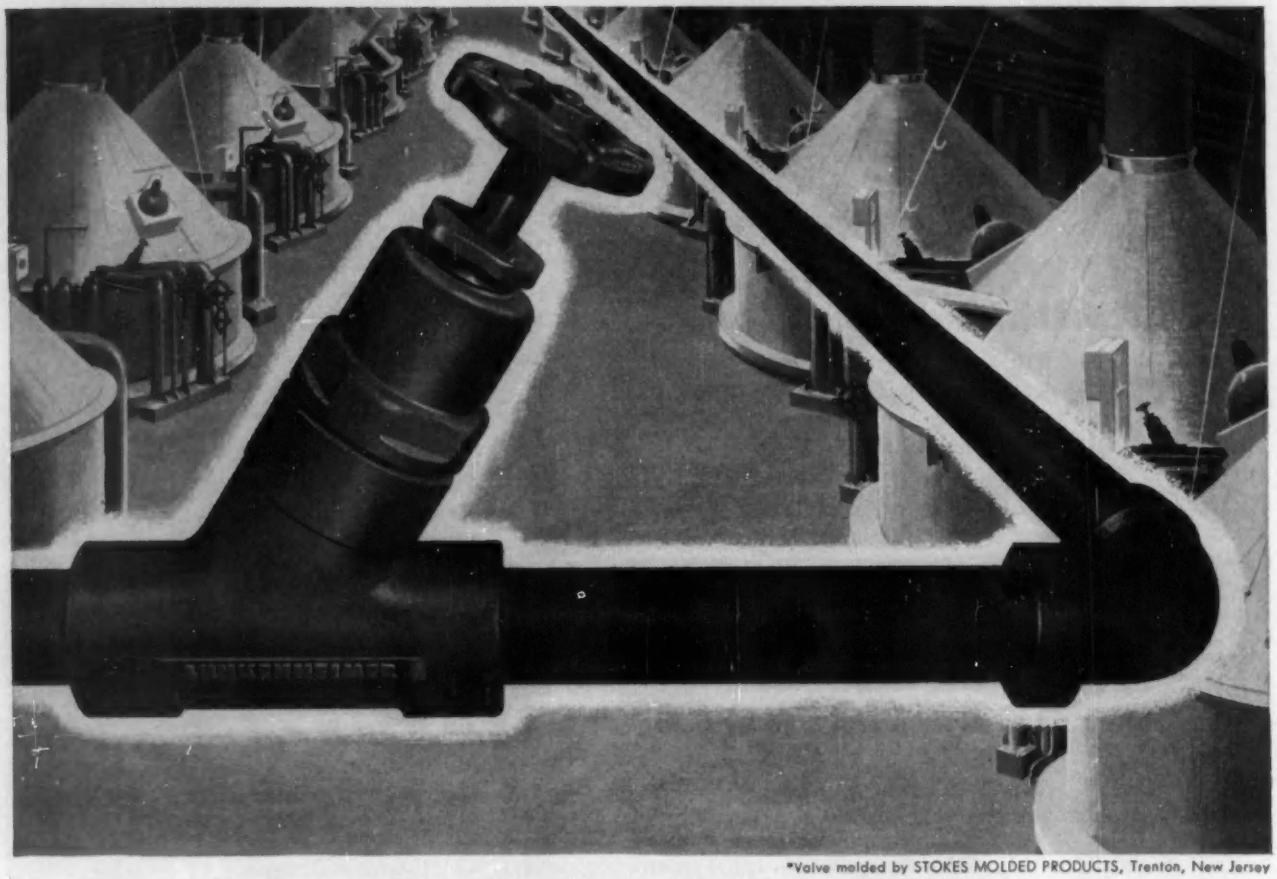
WRITE for free Catalog 101 on Eastman Hose Assemblies.

EXON: each resin engineered for a specific problem

EXON 402-A

specifically to wipe out

corrosion



*Valve molded by STOKES MOLDED PRODUCTS, Trenton, New Jersey

Millions of dollars are saved every year by American industry as unplasticized rigid PVC made from EXON 402-A wipes out corrosion. It has outstanding resistance to alkalis, acids, inorganic salts, and other corrosive fluids.

It outperforms, yet costs less than customary metals in many industrial applications. A tremendously important application, pictured above, is the new LUNCOR VALVE* engineered by The Lunkenheimer Co. It is the first all-molded PVC valve designed by a valve manufacturer.

Easier and less expensive to work with, unplasticized PVC made from EXON 402-A is strong but extremely lightweight compared with most metals. EXON 402-A is unusually versatile. It can be made into sheets, rods, tubes and other structural shapes. These can be cemented or welded... and are readily sawed, sheared, stamped, milled, drilled, planed and rolled on conventional metal or woodworking equipment.

For complete information or technical service on EXON resins, call or write Firestone.

Firestone

CHEMICAL SALES DIVISION
FIRESTONE PLASTICS COMPANY, POTTSTOWN, PA., DEPT. CR
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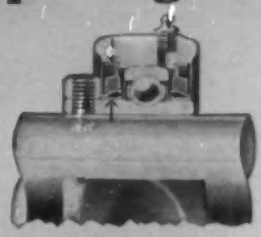
Next time you're bearing comparing . . .

look for these

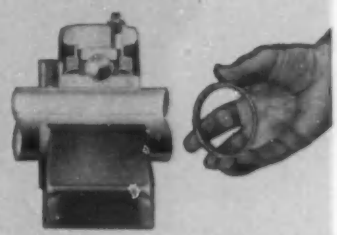
important differences



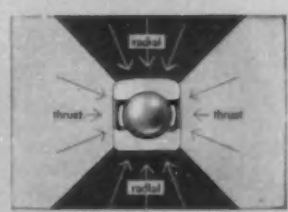
POSITIVE PROTECTION from moisture, dust and dirt is accomplished by seals extending from housing to inner ring. All aligning surfaces are enclosed in lubricant chamber.

Series 200 Ball Bearing Pillow Blocks are part of industry's most complete line of ball and roller bearing blocks.

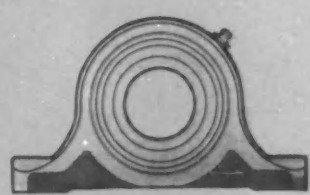
AUTOMATIC RELIEF OF EXCESS GREASE PRESSURE. Patented revolving inner seal members have escape holes enabling excess lubricant to pass out through opening around periphery of seal. No danger of seal being forced out . . . no chance for high pressure to damage bearing.



HIGHEST CAPACITY obtainable to carry heavy radial, thrust or combination loads is provided by single-row, deep-groove design.



GREATER STRENGTH. Base of block is cored to provide uniform metal thickness, assuring a sound casting, free from distortion.



They're all present only in LINK-BELT ball bearings

THESE important bearing differences show up in the performance of your equipment. For instance, a bearing may be subjected to shaft misalignment throughout its working life. Link-Belt's lubricated self-aligning feature assures free rolling . . . maintains maximum efficiency under any service condition. And Link-Belt alone offers that advantage in both ball and roller bearing blocks.

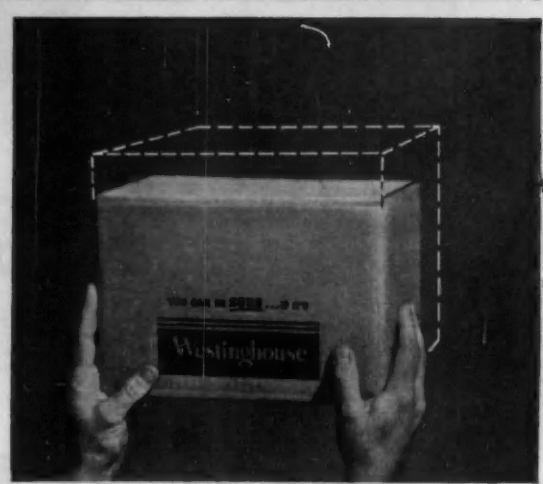
Whatever your bearing requirements, look to Link-Belt. All types and sizes of Link-Belt bearings are available from stock. Ask your Link-Belt office for Data Book 2550, containing complete information on the entire Link-Belt line.

LINK-BELT

Ball and Roller Bearings

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,714

ACTUAL PHOTOGRAPH



Fact 2 . . . up to 40% less space needed to stock. These new motors take less room in your product, too, because they are more compact in design.

New Westinghouse Design Cuts Motor Weight Up to 50%

. . . one important FACT about the new Westinghouse 48-frame fhp motor

Many cost-saving features make the new Westinghouse 48-frame your *best* motor buy. Lighter, smaller and more compact in design, it can be used to advantage in your product.

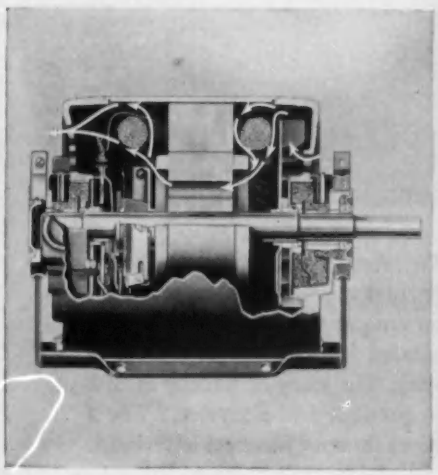
The lighter motor lets you use lighter mountings, lowering material costs. And it's easier to handle, faster to install on assembly lines. In many cases, your shipping costs will be lowered, too.

A new, lighter base—either rigid welded to frame or resilient—assures stronger mounting even under severe operating conditions.

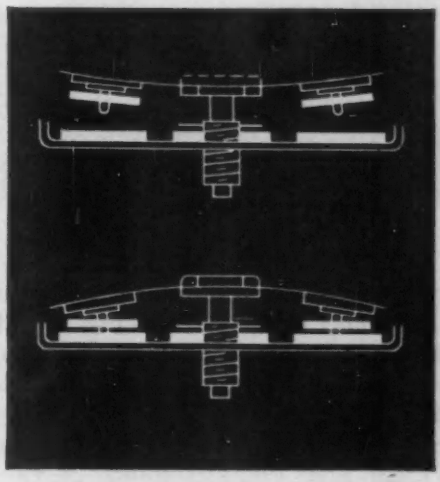
It is the only true all-angle mounting motor. Don't expect all these benefits in any other motor.

The Man With The Facts, your Westinghouse sales engineer, has all the information about this new fhp motor line. Contact him or write for DB-2801 for complete technical data. Westinghouse Electric Corporation, Small Motor Division, Lima, Ohio. J-03019

YOU CAN BE SURE...IF IT'S Westinghouse



Fact 3... straight-through ventilation of this new motor insures cooler operation for longer running periods, even at peak loads.

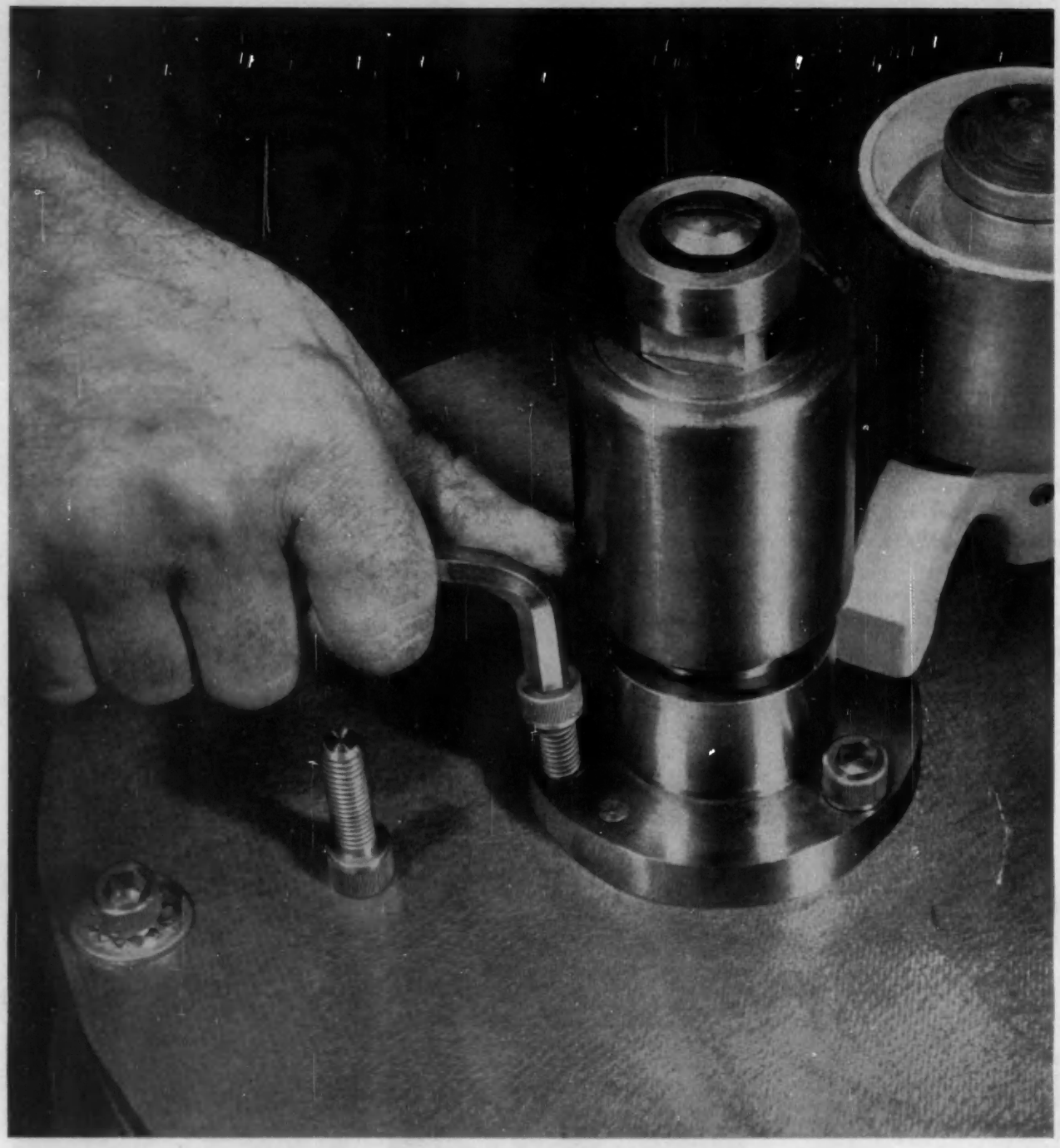


Fact 4... exclusive Thermoguard® overload protection (optional). It opens (top) when overheating occurs ... it resets when cool to resume operation.

Fact 5... Mylar* insulation, one half as thick but possessing greater dielectric strength, provides better moisture protection, greater physical strength.

*DuPont Reg. Trade-Mark

PLATED UNBRAKOS AT WORK

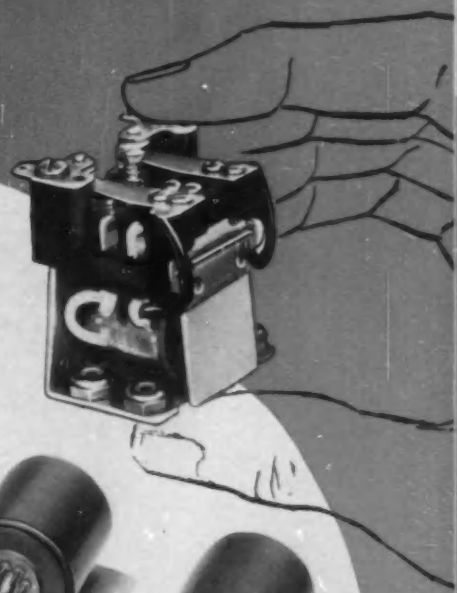


WHY USE A PLATED UNBRAKO SOCKET SCREW? Accuracy of the plated screw —Class 3A thread tolerance after plating. And prompt delivery—shipment of plated UNBRAKOS 7 days after receipt of your order. It is this unique control of quality and delivery that enables us to supply plated UNBRAKO socket head cap screws for this precision centrifugal separator used in the dairy industry. The story of plating at SPS is told in an interesting booklet, "Precision Plating—a product and a service." For a copy, see your authorized industrial distributor or write us on your business letterhead. STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

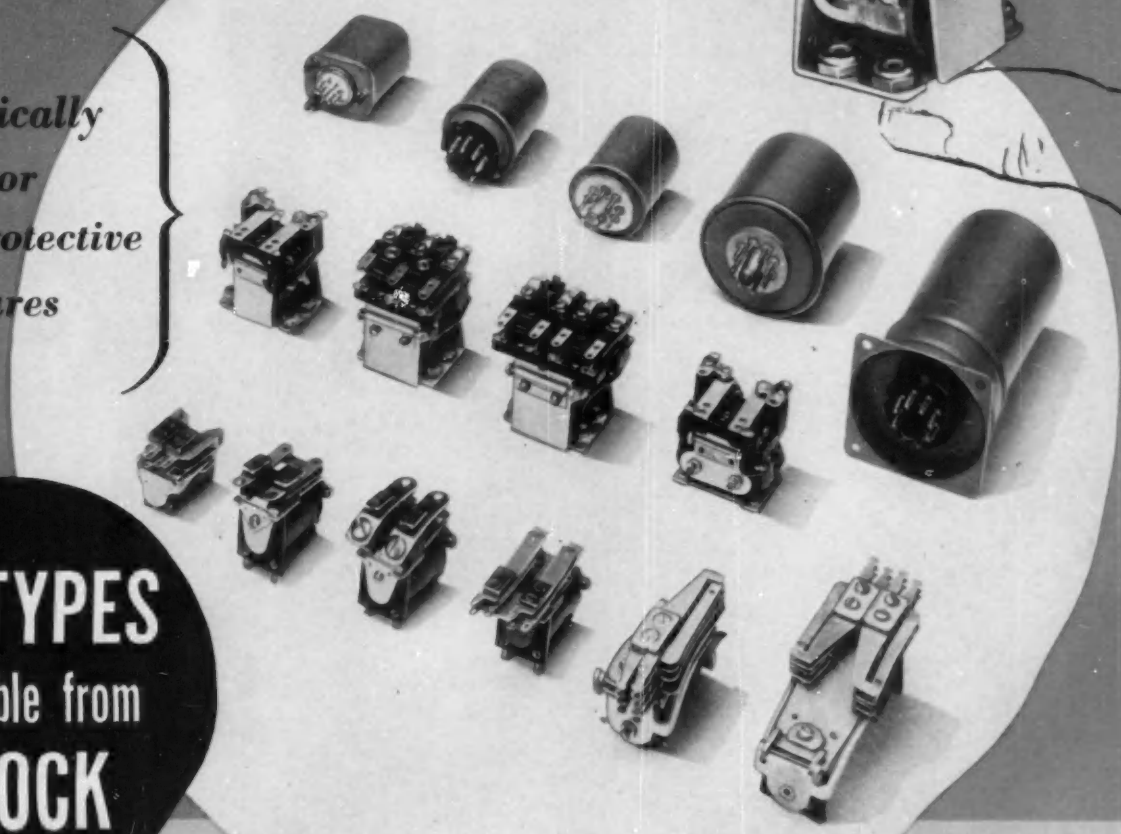
UNBRAKO SOCKET SCREW DIVISION SPS JENKINTOWN, PENNSYLVANIA

OHMITE AMRECON® Relays

HIGH QUALITY, GENERAL-PURPOSE RELAYS FEATURING COMPACTNESS, DEPENDABILITY AND LONG LIFE!



hermetically sealed or dust-protective enclosures



48 TYPES available from STOCK

Current ratings up to 25 amp, AC or DC

When you want the utmost in relay dependability, investigate the Amrecon line. Amrecon relays are designed, produced, and tested in the new, air-conditioned Ohmite plant.

These ruggedly built relays have the ability to handle power loads usually requiring larger, heavier units. They are built to meet rigorous aircraft relay standards, and are particularly adapted to mobile equipment where severe shock and vibration are encountered.

Amrecon relays are available with screw, plug, or solder-wire terminals; in a variety of contact arrangements; with hermetically sealed or dust-protective enclosures. Order from the 48 stock types, or let Amrecon's engineers help you work out special relay applications.

Send for Catalog R-10

OHMITE®
MANUFACTURING COMPANY
3611 Howard St., Skokie, Illinois (Suburb of Chicago)

OHMITE® HIGH CURRENT ROTARY TAP SWITCHES

For your AC power-switching requirements in the 10 to 100 amp range, Ohmite Tap Switches are the finest units available. They are load-break, non-shorting, single-pole switches of unusually compact design.

Numerous design and construction features provide ruggedness and dependability. Silver-to-silver contacts eliminate contact maintenance. The rotor contact is self-cleaning. The switch shaft is electrically "dead"—insulated by a strong ceramic hub. Furthermore, the positive cam-and-roller mechanism for "slow-break, quick-make" action greatly increases contact life.

Ohmite Tap Switches are available with 2 to 12 taps in the single pole, non-shorting type. Two or three switches can be grouped in tandem to form multi-pole assemblies. They are also available in open-type models for both shorting and non-shorting applications.

Write on Company Letterhead for Catalog and Engineering Manual No. 40

OHMITE MANUFACTURING COMPANY
3611 Howard Street, Skokie, Illinois (Suburb of Chicago)

ALL CERAMIC AND METAL

•

NOTHING TO BURN OR CHAR

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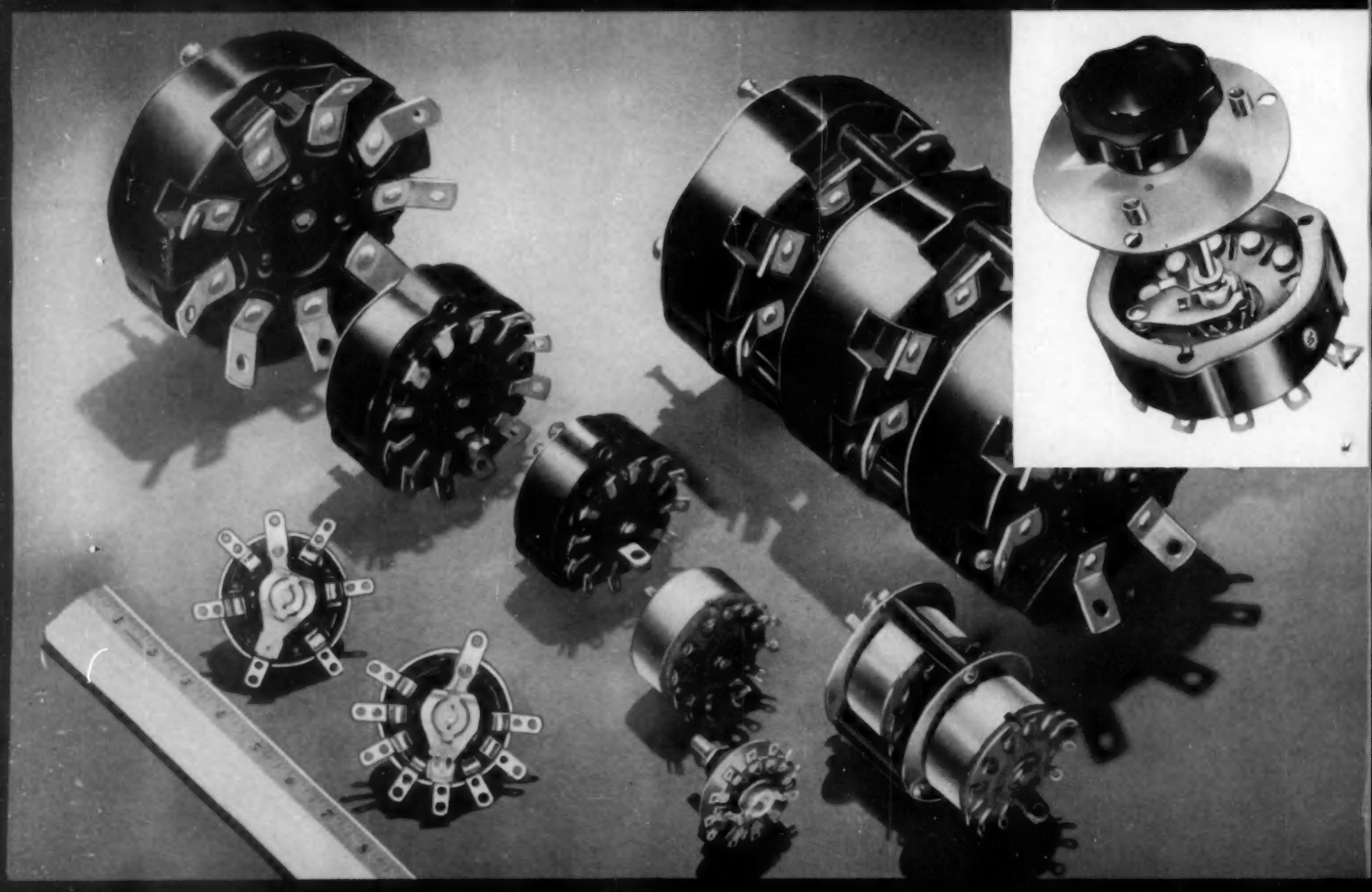
FIVE SIZES—10, 15, 25, 50, AND 100 AMPS

OHMITE® RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES



Want to get un-stuck on production difficulties?

FAIRPRENE®

INDUSTRIAL PRODUCTS

COATINGS OF

"Teflon"* • Silicone rubber • Neoprene
Buna N • GR-S • Natural rubber

ON THESE FABRICS

Nylon • "Dacron"† • Glass
Cotton • "Orlon"‡ • Asbestos

Also sheet stocks without fabric inserts and cements

**Du Pont's trademark for its tetrafluoroethylene resin.*
†Du Pont's trademark for its polyester fiber.
‡Du Pont's trademark for its acrylic fiber.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

There are times when a product should *lose* its grip—improved "release," they call it. Take the case of electric irons used to heat-seal plastic films. Technicians of the Du Pont Fabrics Division suggested *a coated fabric* that proved ideal for covering the heating elements. It had the necessary heat resistance plus excellent "release"—no sticking whatsoever.

If you need a special gasket, seal, diaphragm or protective cloth material in your design—why not try a Du Pont coated fabric or sheet stock? You can obtain the exact combination of properties you need with the proper fabric and coating. Heat resistance with good "release," abrasion resistance with superior flexibility, oil resistance with high strength—these and many more combinations are possible.

We'll be glad to discuss possible application of coated fabrics in your design or on your equipment. Just clip and mail coupon for further information.

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, P57, Fairfield, Conn.

I am interested in Fairprene Industrial Products.

( ) Have a representative call. ( ) Send further information.

Name_____ Title_____

Firm_____

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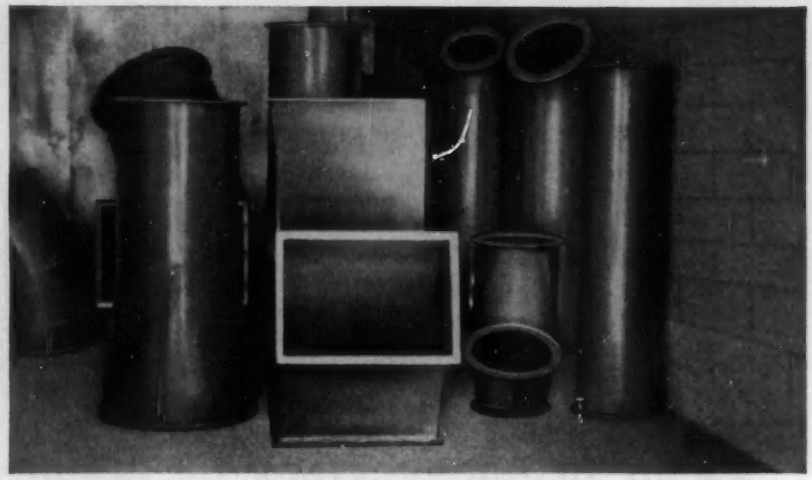
UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

Improvements in applying plastisol coatings

Recent developments in Unichrome vinyl plastisols permit wider use of these protective materials



Large ductwork protected with heavy duty Unichrome Plastisol Coatings. Photo courtesy Kaybar, Incorporated, Hazel Park, Mich.

PLASTISOLS are viscous, liquid compounds which are heat-cured at about 350°F. to produce attractive corrosion-resisting finishes that look and feel like rubber. Problems in applying them formerly limited their use. Now, however, two important developments by United Chromium remove big stumbling blocks.

SPRAYED-ON PLASTISOL

Ability to build up a thick coating capable of withstanding severe service is one of the greatest advantages of plastisols. Until recently, however, thick coatings could be obtained only by dip application. Now, with Coating 5300, a single coat 20 mils thick or multiple coats even thicker can be successfully sprayed to cold vertical surfaces without sagging. If products can be uniformly baked, they can now get a seamless, pore-free coating 5 to 20 times thicker than ordinary coatings. In fact, Coating 5300 can do many jobs for which sheet materials are often specified.

ECONOMICAL COLD DIP PLASTISOL

Unichrome Plastisol Compound 4129, developed particularly for wire goods, satisfies both the needs of the product designer and the production man. It provides a more economical way to produce a durable plastisol finish. 4129 can cut plastisol consumption 50 to 60%. What's more, wire products can be dipped at room temperature and production rates are substantially increased. Without waste, an abrasion resistant coating forms which gives pore-free protection against chemicals, water and other corrosives, and doesn't crack, chip or tear.

IN BRIEF

To the chemical resistance, physical toughness, dielectric strength, sound deadening and speed of curing of Unichrome Plastisols can now be added ability to be applied by almost any conventional production method. More data in Bulletin VP-1. Send for copy.

Matched plating processes geared for better finishing

A matched set of United Chromium-developed processes for copper, nickel and chromium plating is now available to help designers reduce finishing expense and improve quality. It means a unified operation, with three processes that not only work outstandingly well together but also provide cost-cutting benefits individually.

Specifying Unichrome SRHS Chromium, over Unichrome Bright Nickel, over Unichrome Copper is assurance of more economies, less trouble, and a better looking finish for such products as automotive trim, electrical appliances, plumbing fixtures, tubular furniture, to cite a few. Send for details.

New compound cut chromate finishing cost

Switching from a liquid chromate material to newly developed "dry" Unichrome Dip Compound 1081, a well known producer of zinc base die castings collected a big dividend. A yellow, corrosion resistant finish was produced same as before but cost of materials consumed was 40% less than before.

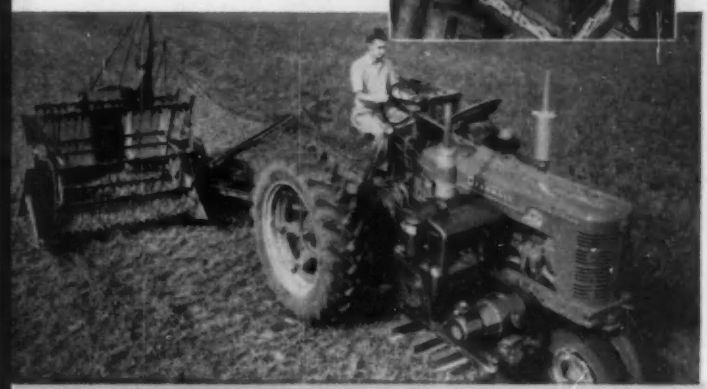
This compound is one of an unusually wide line of chromate finishes provided by United Chromium. With wide choice, it becomes possible to specify a dip finish that means improved quality, greater material economies, or production economies.

Send for data sheet that charts what's now available.

UNITED CHROMIUM, INCORPORATED
A Metal & Thermit Organization
100 East 42nd Street, New York 17, N. Y.
Waterbury 20, Conn. • Detroit 20, Mich.
Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada:
United Chromium Limited, Toronto 1, Ont.

. . . from field-testing harvesters to checking jet starter performance . . . SANBORN OSCILLOGRAPHIC RECORDING SYSTEMS prove their versatility

Research and Development



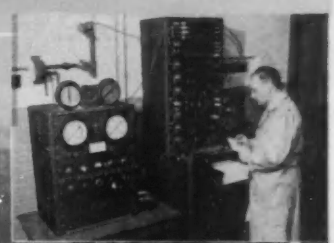
FOR INTERNATIONAL HARVESTER'S ENGINEERING TEST AND DEVELOPMENT DEPT.

A specially housed and shock-mounted Sanborn 2-channel recorder provides dynamic strain measurement data on a field forage harvesting machine, during actual field use. In the photographs, rotor shaft torque and RPM are being recorded, one of several uses International Harvester has found for the Sanborn System in field testing their farming equipment.

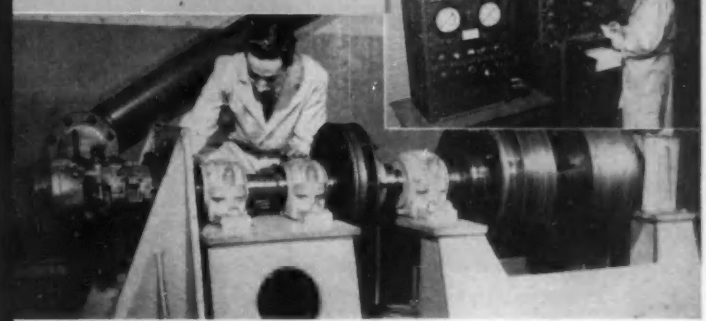
Production Testing

AT ARCH GEAR WORKS, QUINCY, MASS. . . .

A record of tooth regularity of various types of precision gears is obtained on a single-channel Sanborn Model 141 System, used in conjunction with a special gear checking instrument devised by Arch Gear Works. The equipment permits visual spot checking of gears, helps maintain a high rate of acceptability and provides a permanent record of tests often required by customers.



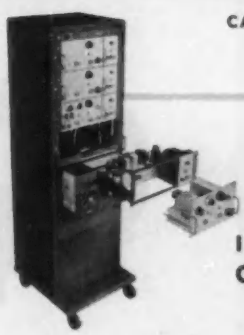
Research and Production Testing



AT G. E.'S AIRCRAFT GAS TURBINE DIV. . . .

Engineers record performance data such as temperatures, pressure, RPM and starting time of jet engine starters, using a modified Sanborn Model 67 System. Six channels of information are recorded in this four-channel unit, equipped with three DC amplifiers, one Triplexer, a four-channel DC Converter, two-channel zero suppression network and two modified strain gage amplifiers. The data also provides G. E. engineers with an indication of the performance of all production units.

These typical applications indicate the scope of usefulness of standard and modified Sanborn Recording Systems. Wherever accurate, permanent, graphic registration of electrical phenomena in the 0-100 cps range is required, the *versatility* and *flexibility* of Sanborn one-, two-, four-, six- and eight-channel systems will prove invaluable. A wide variety of readily interchangeable, plug-in preamplifiers enable *one* basic system to meet *many* recording requirements. Standard instrument features include inkless recording in true rectangular co-ordinates, high torque galvanometer movement, time and code marking, and a choice of nine chart speeds.

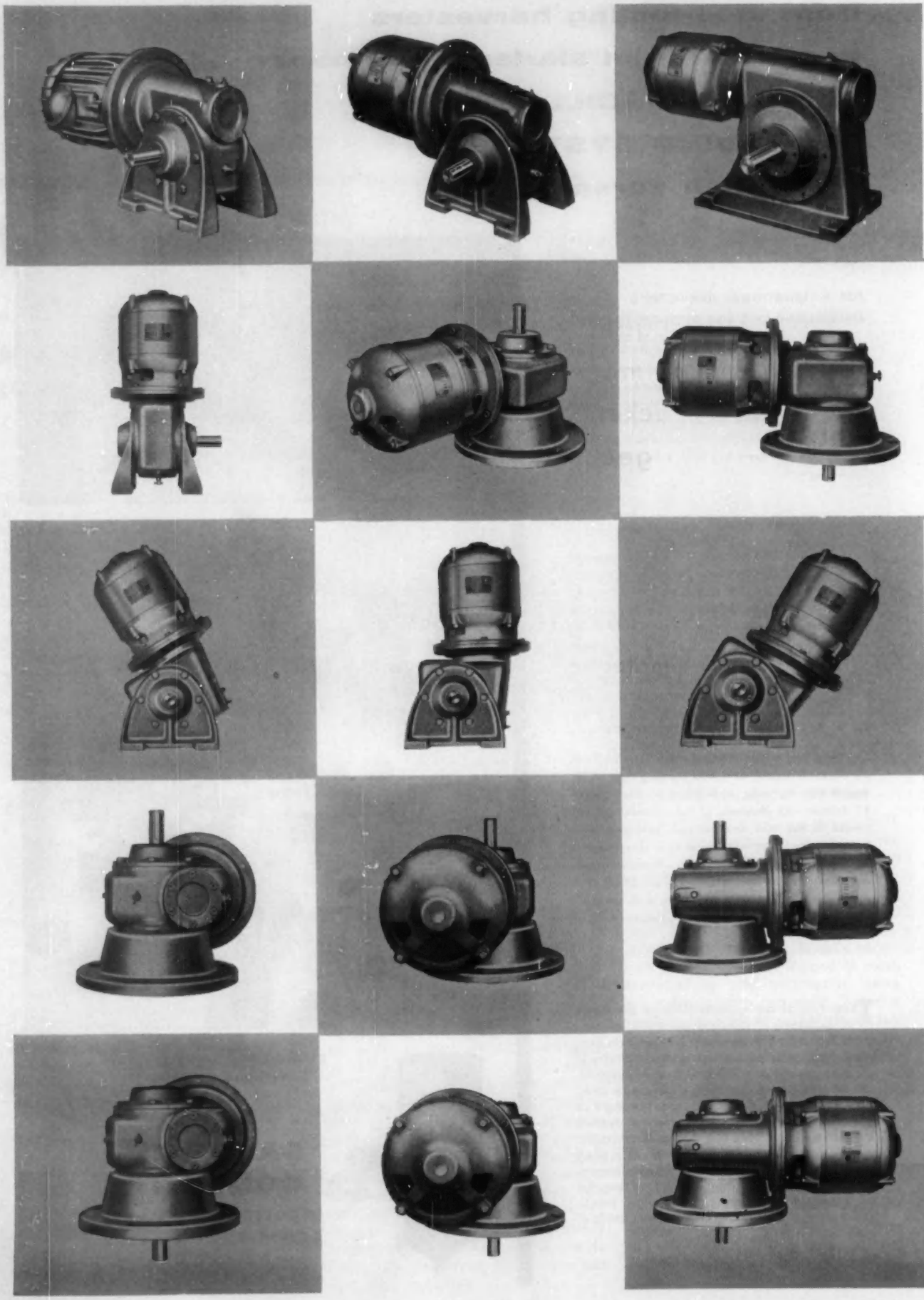


CATALOG AND TECHNICAL DATA AVAILABLE ON REQUEST

SANBORN COMPANY

INDUSTRIAL DIVISION

CAMBRIDGE 39, MASS.



Just to suggest the practically unlimited variety of mounting positions possible with Elliott Crocker-Wheeler right-angle single worm reduction gearmotors.

- a-c or d-c • ½ to 30 hp • foot- or flange-mounted
- with any motor enclosure • for all AGMA service classifications

Your Elliott representative has complete information...

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310 Haas-Howell Bldg.
Birmingham
1600 Second Ave. S.
(General Machinery Co.)
Boston 35
1330 Soldiers Field Rd.
Buffalo 2
807 Crosby Bldg.
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1916 Liberty Life Bldg.
Chicago 30
6100 N. Pulaski Rd.
Cincinnati 6
2337 Victory Parkway
Cleveland 14
1319 National City Bank Bldg.
Dallas 5
5738 Central Expressway
Denver 9
308 Union National Bank Bldg.
Detroit 26
1820 Dime Bldg.
Duluth
617 North 10th Avenue, East
Houston 3
1209 Hutchins Street
Indianapolis 8
54 West 30th Street
Kansas City 14
514 West 75th Street
Los Angeles 15
714 West Olympic Blvd.
Milwaukee 3
744 North 4th Street
Minneapolis 3
540 Plymouth Bldg.
Newark 7
4th Avenue and 13th Street
New Orleans 13
256 Lee Circle Bldg.
New York 13
271 Church Street
Philadelphia 2
226 South Sixteenth Street Bldg.
Pittsburgh 19
718 Frick Bldg.
Rockford, Ill.
403 Central National Bank Bldg.
Salt Lake City
Zion Savings Bank Bldg.
San Francisco 4
1504 Russ Bldg.
St. Louis 3
1221 Locust Street
Seattle 1
1101 Vance Bldg.
Syracuse 2
317 State Tower Bldg.
Tulsa 3
910 Petroleum Bldg.
Washington 1, D.C.
Washington Gas Light Bldg.

ELLIOTT Company • JEANNETTE, PA.
CROCKER-WHEELER DIVISION

WS-7

4 Times the Life-Span of "Gray" Iron

Harnischfeger gets longer life and easier fabrication from Ductile Cast Iron

In solving a machining problem, Harnischfeger Corporation discovered how to greatly increase life of sheaves handling wire rope on their overhead cranes.

The problem arose in machining sheaves of gray cast iron. Chill at the top and corners of rope grooves caused cutting tool breakage.

When Harnischfeger annealed these castings to improve machinability, the base or bottom of the rope grooves were softened. Ranging from 140 to 196 BHN, the softened grooves wore out prematurely and frequent replacements were needed . . . wasting valuable hours of production time.

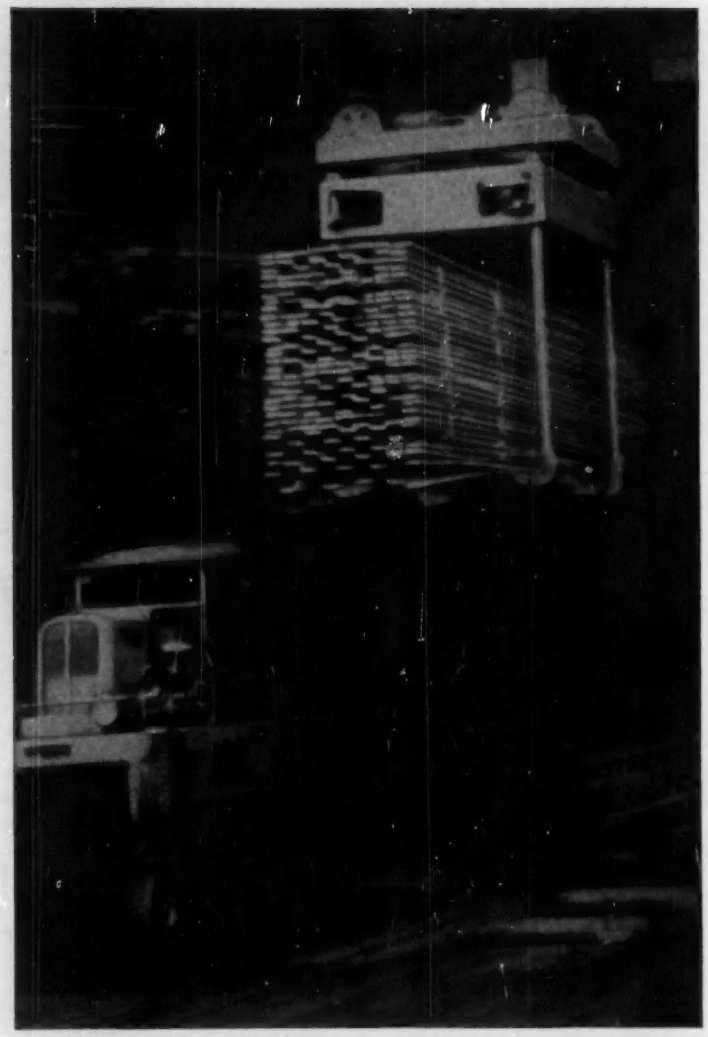
Ductile Cast Iron the answer

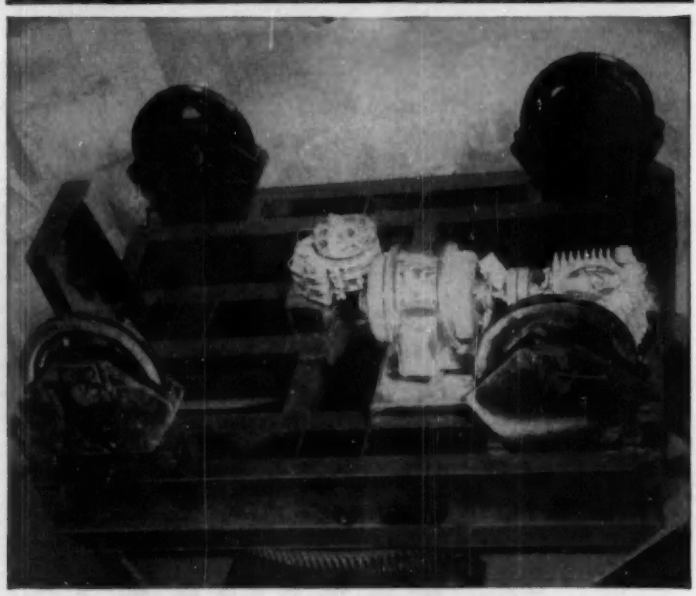
Ductile iron, which has excellent wear resistance, solved the problem.

Although the hardness of the Ductile Cast Iron was higher (240-269 BHN) than that of cast iron, it was free of chill at the edges and machined readily. But especially important in handling wire rope, the wear resistance provided by Ductile Cast Iron gave the sheaves a 4 to 1 longer life than gray iron.

This is a simple example, showing how you get multiple savings by using Ductile Cast Iron. For here's a material with the castability of cast iron, and properties similar to those of cast steel.

Get all the facts about the impact strength, wear resistance and machinability of this economical cast iron. It's several times stronger and tougher than gray cast iron. Send for a copy of "DUCTILE IRON, The Cast Iron THAT CAN BE BENT!" It's filled with helpful data. Write for your copy now.





Way to cut downtime of overhead traveling crane. Grapple shown at work in lumber shed is equipped with sheaves of Ductile Cast Iron. Readily machinable, but resistant to wear from wire rope, they outlast gray iron sheaves 4 to 1. Equipment produced by Harnischfeger Corp., Milwaukee 46, Wisc.

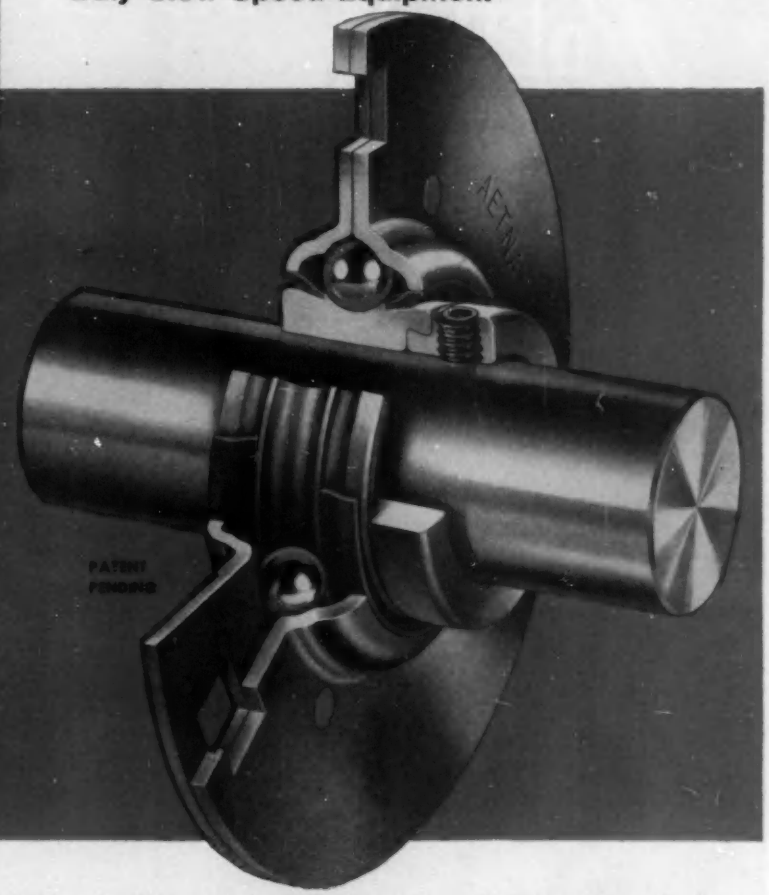
DUCTILE IRON

ductile iron . . . the cast iron that can be twisted and bent

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.

THE NEW AETNA ADAPTER BEARING

A Complete, Single-Package Ball Bearing Unit That Brings Low-Cost, Anti-Friction Efficiency Within The Range Of All Light-Duty Slow-Speed Equipment



You're looking at the better BUDGET bearing . . . the new Aetna AG-Series Adapter Bearing . . . keyed to the cost problems of light-duty slow-speed equipment designers.

In this one thrifty *package* you get a complete, compact, easy-to-install ball bearing unit . . . adaptable to an amazing variety of machine and equipment applications. It can be mounted wherever shafts can be supported . . . on sheet metal or any other economical, semi-rigid structural members. Pre-lubricated and uniquely sealed it assures long, dependable, trouble-free operation with minimum servicing.

Check and compare the Aetna Adapter Bearing features below. Chances are you could write this unit into YOUR specs with attractive cost-reducing product-improving results. Mail coupon today!

SAVES MONEY

SAVES TIME

SAVES SPACE

FEWER PARTS • Simplified, compact, space-saving design. Flange and outer bearing race—ALL-IN-ONE. Full ball complement. No retainer.

EASY MOUNTING • *Package* construction—needs no pre-installation adjustments, fitting or reassembly. Eccentric locking collar for easy, quick mounting without auxiliary positioning devices, without shaft shouldering or machining.

PRE-LUBRICATED • Generous, factory-packed lubricant chamber assures maximum life and operating efficiency, minimum servicing.

EXCLUSIVE SEALS • Dirt-proof, leak-proof, one-piece Buna-N seals (of Aetna-originated design) are self-contouring, free-running, self-aligning, corrosion and rust-free; provide positive contact under all conditions of misalignment.

SELF-ALIGNING • Compensates for shaft or structural member deflections and misalignment. Takes radial, thrust or combined loads.

RUGGED DURABILITY • Inner and outer races case hardened for high fatigue and shock load resistance. Heavy gauge pressed steel housing.

OTHER AETNA LOW-COST BEARING UNITS

Sprocket Idler Unit

Belt Idler Unit

Grain Drill Unit

Disc Harrow Unit

Aetna

BALL BEARINGS

ROLLER BEARINGS

MISCELLANEOUS PARTS

AETNA BALL AND ROLLER BEARING CO.
Div. of Parkersburg-Aetna Corp. • 4600 Schubert Ave • Chicago 39, Ill.
WITHOUT OBLIGATION . . . I want to know more about your new line of low-cost mounted bearing units. Please have a representative call.

Name_____

Company_____

Address_____

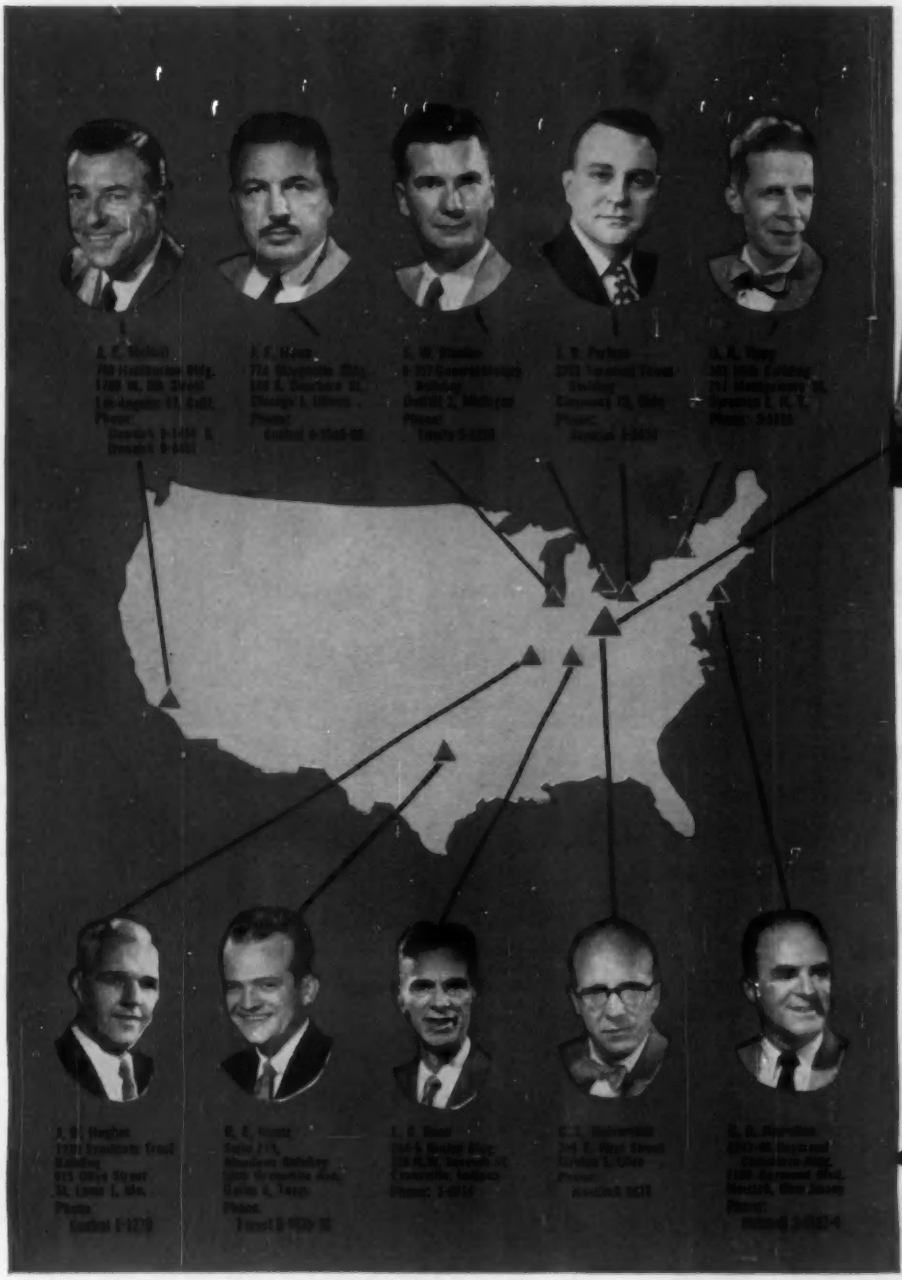
City_____ Zone_____ State_____

DELCO Job-Fitted Electric Motors

DAYTON, OHIO

Meet the motors with the most to solve your problem . . . Delco Job-Fitted Electric Motors! Whatever your power problem, there's a motor in the Delco line that's the ideal solution. We've got fractionals and integrals of every description. Our list of customers reads like the bluebook of American industry. They like our product, they like our fast delivery and service throughout the world. They like Delco dependability!

Meet the man who job-fits your Delco electric motors. Whatever your electric motor requirements, he is "at your service." He's



Frank C. Carpenter, General Sales Manager, Delco Products Division, General Motors Corporation, Dayton 1, Ohio
Phone: Hemlock 9411

DELCO Regional Sales Managers

DAYTON, OHIO

backed by Delco's years of experience and skill in design and engineering, quality construction and precision workmanship.

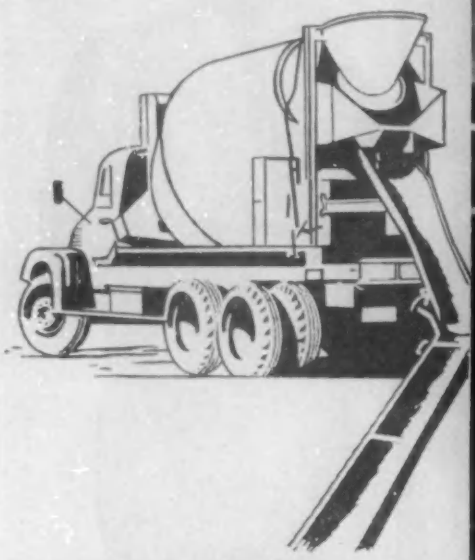
Which of these men is nearest you? Get in touch with him by phone, telegram or letter. He's "at your service."

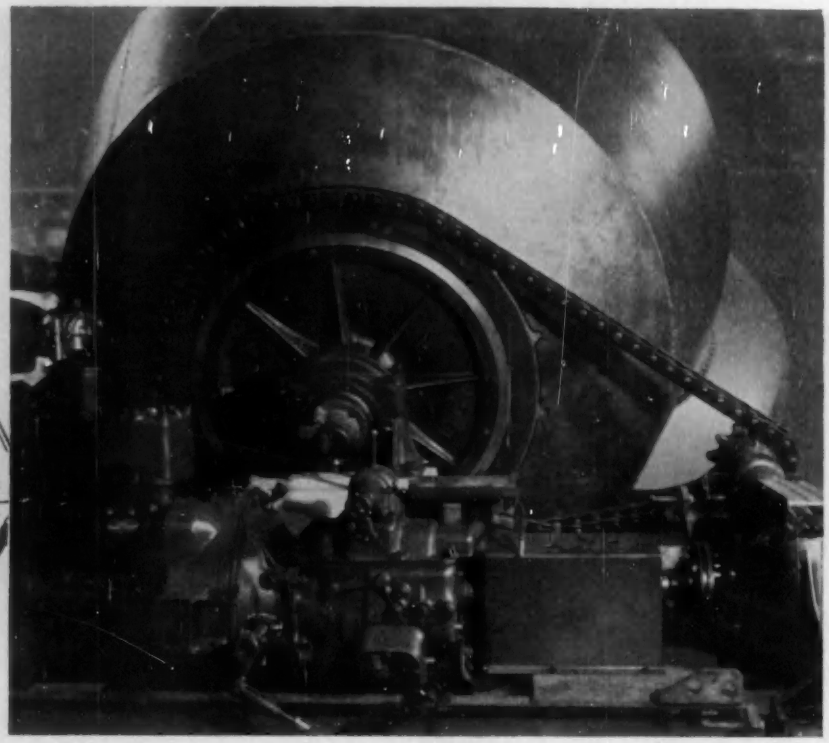
GM GENERAL MOTORS DELCO

DELCO *Electric* MOTORS

DELCO PRODUCTS, DIVISION OF GENERAL MOTORS, DAYTON, OHIO

Proved best by Performance!





good mixers rely on JEFFREY chains and sprockets

Many manufacturers of concrete mixers have found that a good chain drive will do a top job of turning the mixing drum. But not just "any" chain will do: The inclined angle of the drives makes special demands.

Jeffrey chain with offset sidebars works better than straight sidebar chain. Jeffrey STEELCARVE sprockets are cut just right to handle an inclined drive, and they stand up under the most rigorous conditions.

Several major mixer companies rely on Jeffrey for their chain drives and sprockets. They find that Jeffrey equipment gives excellent continuous service.

Jeffrey STR STEELCARVE sprockets. Top view shows Jeffrey chain and a STEELCARVE sprocket on a high quality mixer.

Whether you manufacture concrete mixers or other machines, you will find Jeffrey's superior chain and sprockets give powerful, long-lasting performance on your products. Jeffrey engineers can help solve your special transmission problems now.

THE JEFFREY MANUFACTURING CO.

ESTABLISHED 1877

Columbus 16, Ohio

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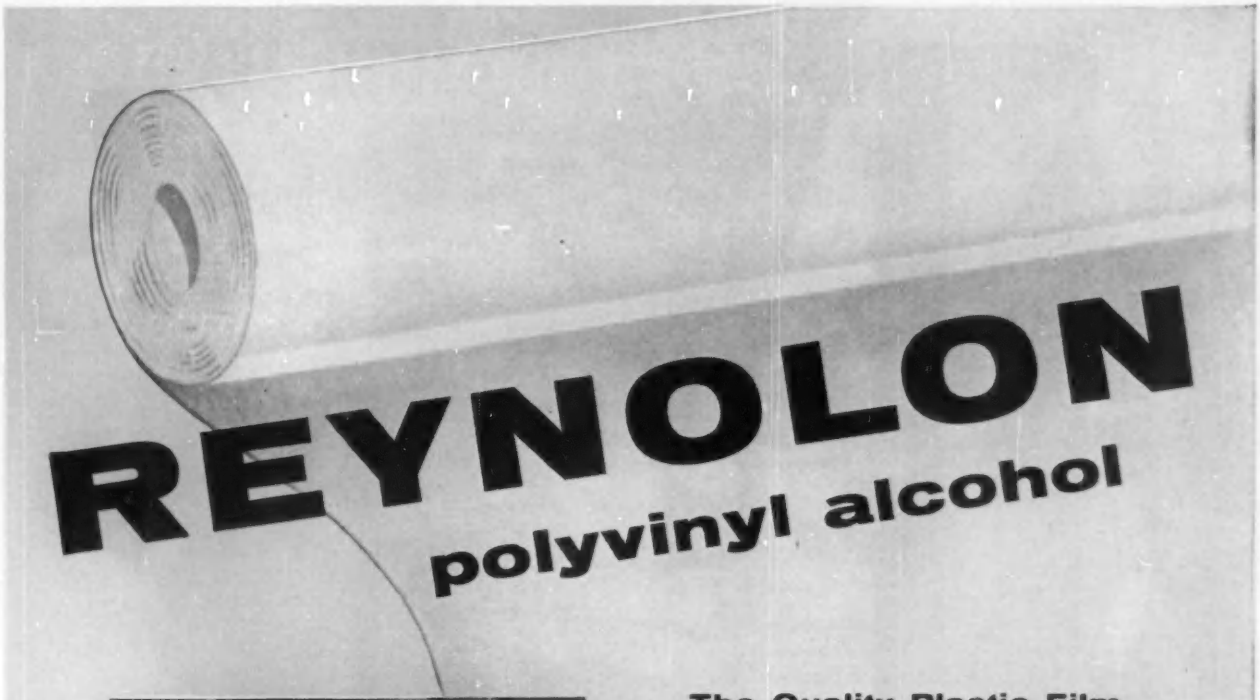
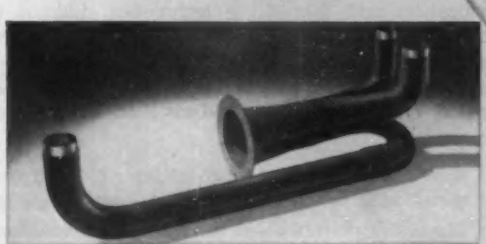
IF IT'S MINED, PROCESSED OR MOVED . . . IT'S A JOB FOR JEFFREY!



REYNOLON
polyvinyl alcohol

Preparing a reinforced plastic layup for breakaway molding of ducts and piping. When layup is completed, part is then spirally wrapped with polyvinyl alcohol tape for curing.

Reynolon 4000 Series Polyvinyl Alcohol Film used in bag molding sections of reinforced plastic piping and duct work into continuous lengths.



Complete fabrication sections of reinforced plastic pipe.

The Quality Plastic Film for Faster, Lower Cost Production by the Bag Molding Process of Reinforced Plastics

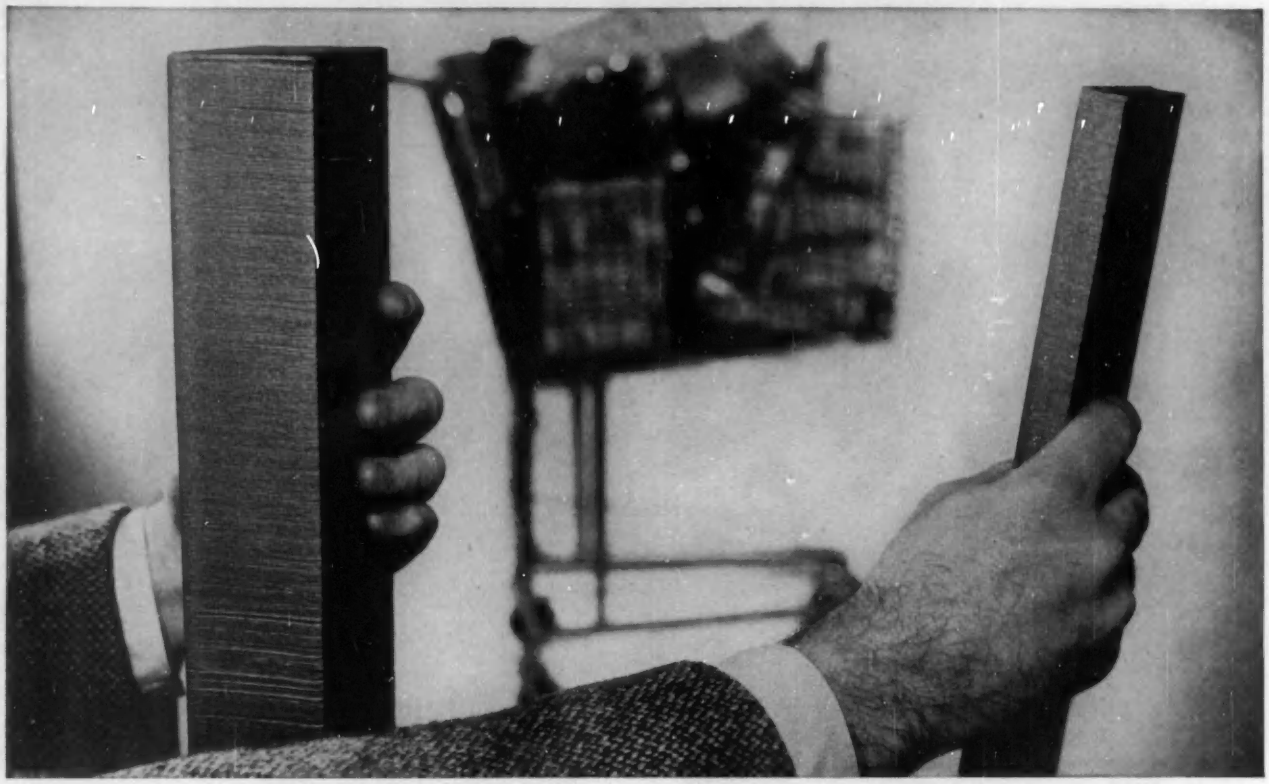
There's no need to delay production until matched metal molds are ready when you use Reynolon Polyvinyl Alcohol Film and the bag-molding method. Bag molds are also less costly than matched metal dies—so you save both time and money. Reinforced plastic parts can also be bag molded faster and at lower cost than by contact molding.

It will pay you to investigate the advantage of bag molding and also the benefits offered by highest quality, super clear, strong Reynolon Polyvinyl Alcohol Film. Reynolon Polyvinyl Alcohol, Polyvinyl Chloride, Polyethylene and laminates of Polyethylene and Cellophane are all available in many standard specifications or can be economically produced for your specialized requirements. Our Technical Product Development Service is also available to you without obligation.

Photos courtesy of Chetron Corporation, Los Angeles, California

For complete information, contact your nearest Reynolds Metals Company office or write

PLASTICS DIVISION
REYNOLDS METALS COMPANY
3802 GEORGIA STREET • GARY, INDIANA



Which is the ECONOMY SIZE?

3 times stronger than carbon steel, Lukens "T-1" steel slashes equipment weight, reduces costs

The lighter weight, reduced thickness of Lukens "T-1" steel, in comparison to heavier, thicker plates of ordinary carbon steel, makes possible substantial over-all savings in material, fabrication, construction and maintenance. Where designers and engineers can take full advantage of it, this unique, low-carbon, quenched and tempered alloy plate steel offers many superior properties. With a yield strength three times greater than ordinary carbon steel, Lukens "T-1" steel can cut costs by reducing weight and still allow increased payloads and efficiency.

Equipment fabrication is no problem with Lukens "T-1" steel. It is readily welded without preheating or stress relieving; equipment can easily be fabricated, modified or repaired at the field site. Its exceptional toughness and resistance to wear and impact lowers maintenance costs and lengthens equipment life. Additional savings are possible where Lukens' range of steel plate sizes—including the widest and heaviest available anywhere—make possible the use of wider sizes that require fewer welded seams.

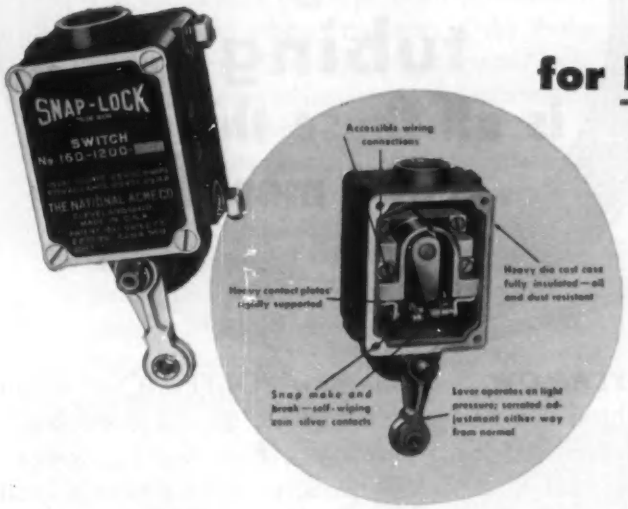
Lukens "T-1" steel is the most recent addition to Lukens' complete line of carbon, alloy and clad steels. Its unusual combination of properties suit it especially to application in pressure vessels, bridges, shipbuilding, construction machinery and general industrial equipment. On problems of design, selection, application and fabricating techniques, Lukens offers full technical assistance. If you would like further information on Lukens "T-1" steel, write for Bulletin 765 on its properties, characteristics and applications. Address: Manager, Marketing Service, 775 Lukens Bldg., Lukens Steel Co., Coatesville, Pa.

LUKENS **"T-1" STEEL** THE NEWEST IN A COMPLETE LINE OF ALLOY STEELS

LUKENS STEEL COMPANY, COATESVILLE, PA.

need limit switch help?

you'll find it in National Acme's Complete Line of Switches


SNAP-LOCK
SWITCH
No. 160-1200
THE NATIONAL ACME CO
Accessible wiring connections
Heavy die cast case fully insulated—oil and dust resistant
Heavy contact plates rigidly supported
Snap make and break—self-wiping arm silver contacts
Lever operates on light pressure; serrated adjustment either way from normal

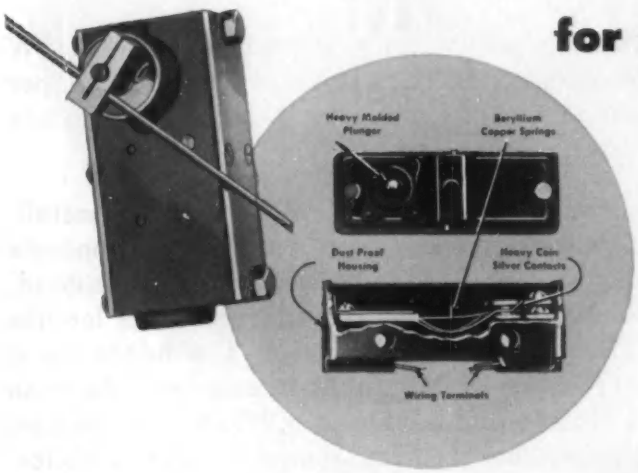
for heaviest-duty installations

SNAP-LOCK'S basic design simplicity and ruggedness have earned acceptance by the majority of manufacturers, including machine tool builders, as the standard for original equipment use.

- **Positive locking in either position.**
- **Normally closed operation of either side.**
- **Use on AC or DC.**
- **Standard Models include short travel, neutral position, water resistant and hazardous location styles.**
- **Wide variety of operating lever and mounting styles.**

(Left) Electrical side (completely sealed from mechanical operating side)

CATALOG EM-51 GIVES COMPLETE SPECIFICATIONS



for feather-touch applications

National Acme SUPER-SENSITIVE switches are especially suited for limit switch use—counting devices, safety switches, gauging devices, relays, liquid level and pressure controls—and countless other uses.

- **Compact, durable, light contact.**
- **For AC line voltage use.**
- **Rotary, oscillating and plunger type models can be mounted in any position.**
- **Ordinary vibration will not interfere with operation.**

(Left) Micro Switch in Namco protective housing.

ASK FOR CATALOG EM-50-S

Also of great importance to our customers is the vast specialized engineering experience available to them from National Acme . . . to help determine correct capacities, housings, space, type of mountings and to assist with special problems for the most practical application at lowest cost—of National Acme Limit Switches and "Stellite"-weld Solenoids.

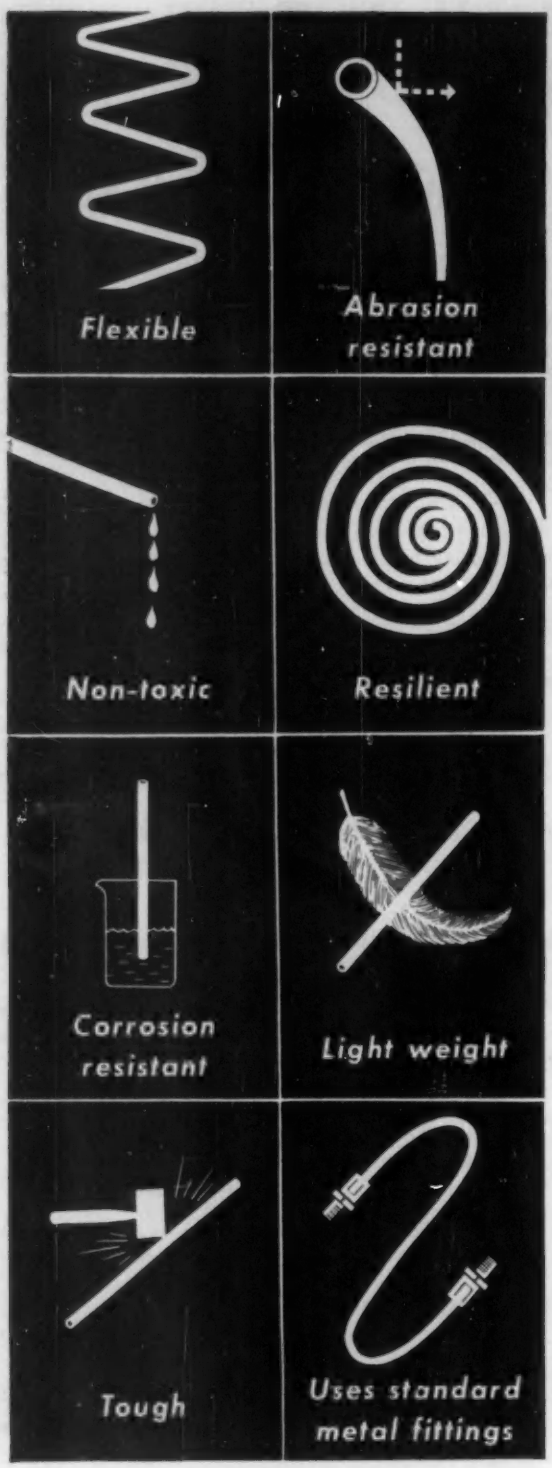
May we assist you in designing these trouble-free switches into your equipment

See us at the Chicago Show—Booths 324 and 705

ELECTRICAL MANUFACTURING DIVISION

THE NATIONAL ACME COMPANY

170 EAST 131st STREET • CLEVELAND 8, OHIO



NYLAFLOW . . . the new POLYPENCO® nylon tubing . . . now permits you to get all the advantages of nylon in pressure lines for lubricants, air, fuel and oil, coolants, process streams, and hydraulic fluids.

With all its superior performance, NYLAFLOW tubing costs less in some small sizes than copper tubing. And it costs much less than flexible rubber hose.

Another thing, NYLAFLOW costs less to install. There's no pre-bending . . . no intermediate fittings . . . no flexible hose attachments. Instead, NYLAFLOW can be run in continuous lengths and connected simply by using a standard metal compression or flare fitting at each end. Because it's flexible and light weight, NYLAFLOW tubing also simplifies prefabrication of tubing assemblies.

NYLAFLOW tubing is now available in stock diameters and lengths. There are two grades: Type T with a tested bursting strength of 1,000 psi; and Type H, 2,500 psi. The tubing also is available in colors for color coding.

SEND FOR NEW *NYLAFLOW* TUBING BULLETIN

THE POLYMER CORPORATION of Penna. • Reading, Penna.

POLYMER *NYLAFLOW* TUBING

. . . nylon . . . Teflon† . . . and other non-metallic shapes

In CANADA: Polypenco, Inc., 2052 St. Catherine W., Montreal, P.Q.

†Teflon is the trademark for DuPont tetrafluoroethylene resin

*NYLAFLOW is the trademark for The Polymer Corporation's nylon tubing

ANOTHER UNUSUAL PROBLEM SOLVED BY LORD...

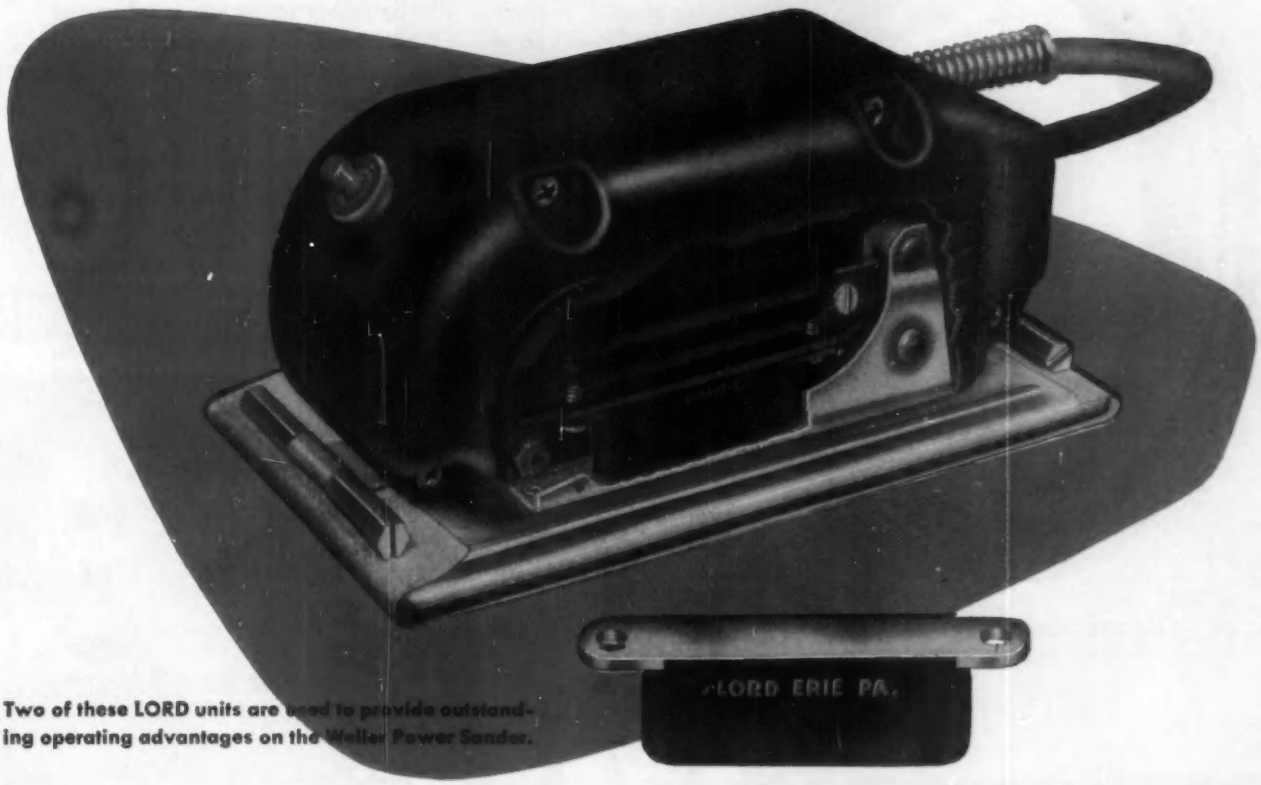
IMPROVED SANDING PERFORMANCE WITH LORD VIBRATION CONTROLS

The coordinated efforts of LORD development engineers and product engineers of the Weller Electric Company have resulted in several "built-in" performance advantages in the outstanding Weller Power Sander.

Lord Vibration Control units control the sanding plate action by (1) maintaining alignment of the plate to achieve straight-line motion, (2) eliminating vertical "bounce", and (3) transferring even pressure to all points of the sanding plate. In addition to these advantages, the flexibility of LORD units adds greatly to the service life of this sander by eliminating damaging rigid construction.

The LORD application on the Weller Sander is typical of many LORD contributions to better product performance through bonded-rubber vibration control units.

LORD is continually presenting new concepts in practical, efficient vibration control. Why not investigate the advantages LORD units will bring to your products? Simply contact the LORD Field Engineer nearest you or LORD MANUFACTURING COMPANY, ERIE, PENNSYLVANIA.



Two of these LORD units are used to provide outstanding operating advantages on the Weller Power Sander.

NEW YORK, N. Y. - Circle 7-3326 • PHILADELPHIA, PA. - LOcust 4-0147
CLEVELAND, OHIO - SUperior 1-3242 • DAYTON, OHIO - MIchigan 8871
DETROIT, MICH. - TRinity 4-2060 • CHICAGO, ILL. - MIchigan 2-6010
DALLAS, TEXAS - Riverside 3392 • LOS ANGELES, CAL. - HOllywood 4-7593
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LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

LORD
BONDED RUBBER

designers and producers of bonded rubber products since 1924

KLOZURE* OIL SEALS

protect the pitch bearings on Piasecki's newest helicopters

KLOZURE Finger Spring Model 53 with silicone sealing element and felt washer.

In designing the pitch bearing assembly of the new H-21 cargo and troop transport helicopter, Piasecki engineers needed a dependable oil seal which would protect the needle bearings in this assembly under the most severe flight conditions . . . at temperatures ranging from −65°F. to +160°F.

After exhaustive tests, Piasecki engineers selected our finger spring KLOZURE Model 53 with silicone sealing element and felt washer. This superior oil seal gave *positive* bearing protection under *all* operating conditions—dust and contaminants were sealed out, the lubricant was sealed in.

Let us show you how Garlock KLOZURES can solve your sealing problems. There's a proven KLOZURE model for every bearing application. For complete information, contact the Garlock office nearest you or write for KLOZURE Catalog 10.

THE GARLOCK PACKING COMPANY, PALMYRA, N. Y.

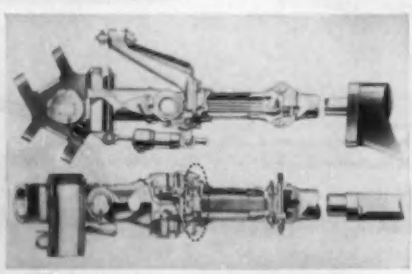
Sales Offices and Warehouses: Baltimore • Birmingham • Boston • Buffalo • Chicago Cincinnati • Cleveland • Denver • Detroit • Houston • Los Angeles • New Orleans • New York City • Palmyra (N.Y.) • Philadelphia • Pittsburgh • Portland (Oregon) • Salt Lake City • San Francisco • St. Louis • Seattle • Spokane • Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

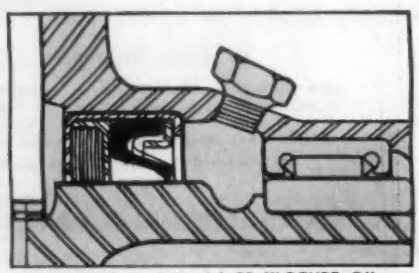
GARLOCK

*Registered Trademark

Complete rotor hub assembly for H-21 helicopter showing 3 pitch housing assemblies.



Pitch housing assembly cut-away to show pitch shaft and bearing assembly.



Installation of Model 53 KLOZURE Oil Seal on the pitch shaft needle bearing.

In Building it's...

REVERE ALUMINUM

To manufacturers whose building products are competing for a place in the more than a million homes, farm buildings, schools, apartments, office and public buildings that are going up this year, Revere Aluminum offers attractive new opportunities.

It offers the ultimate user the advantage of strong, light-weight products that are high in serviceability and attractiveness and low in their need of upkeep. It offers the manufacturer almost unlimited scope in design plus the competitive feature of ready workability for low-cost and fast production.

Revere Aluminum is available in the forms of tube, extruded products, coiled and flat sheet, circles, blanks, awning stock, bus bar, forgings, Lockseam tube, rolled shapes, and foil. Revere Copper and Brass Incorporated, Founded by Paul Revere in 1801, 230 Park Avenue, New York 17, N. Y.

REVERE KNOWS ITS A-B-C's

ALUMINUM BRASS COPPER

Teflon-impregnated U. S. Braided Asbestos Packing

U. S. TEFLON-impregnated braided asbestos packing is designed for service on reciprocating rods and plungers, valve stems, and centrifugal pumps handling corrosive acid and caustic solutions. TEFLON is completely inert in the presence of almost *all* chemicals. The long-fibre asbestos yarn braided into coil form is thoroughly impregnated with TEFLON and provides the proper density, minimizes friction and wear of rods or shafts.

U. S. 35% TEFLON-impregnated braided packing comes in 2 styles: No. 135 (White Asbestos) for handling light acids, caustics and all chemicals. No. 134 (Blue Asbestos) for handling chemicals of a higher concentration. Order from any of our 27 strategically-located District Sales Offices, selected distributors, or write address below.

"U. S." Research perfects it . . . "U. S." Production builds it . . . U. S. Industry depends on it.

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION · ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes Molded and Extruded Rubber and Plastic Products • Protective Linings and Coatings • Conductive Rubber • Adhesives • Roll Coverings • Mats and Matting

Miller

HIGH PRESSURE HYDRAULIC CYLINDERS

Provide Desired Thrusts Up To 160 Tons Plus!

HARD CHROME PLATED PISTON RODS
Prevent Scratch-Damage, Nicks and Rust

SOLID STEEL HEADS, CAPS and MOUNTINGS
Eliminate Breakage

Immediate Delivery on Large Selection

Most complete quality line ever offered for 2000-3000 psi heavy duty service. Bores up through 12", strokes up to 22 feet, 19 standard mounting styles. Millions of maintenance-free strokes per cylinder *proven*. Available in single and double rod end, cushioned and non-cushioned, oversize rod, and "high temperature" service cylinders.

Over 2,000 selections—covering 17 popular mounting styles in 1½" through 5" bores and 1" through 36" strokes—now available for **immediate shipment.** Miller Air Cylinders also in stock for immediate shipment.

Write For Catalog and Stock List

DIRT WIPER SEALS
Protect Rods, Seals, Bushings

Standard Leather Cup Seal Assembly Shown Is Interchangeable With Miller Standard Piston Ring Piston Assembly

WRITE FOR CYLINDER BULLETINS H-104 and A-105

Complete Miller cylinder line includes: air cylinders, 1½" to 20" bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

MET J. I. C. HYDRAULIC STANDARDS years before their adoption in 1949.

SPACE-SAVING SQUARE DESIGN originated by Miller in 1945.

SALES AND SERVICE FROM COAST TO COAST

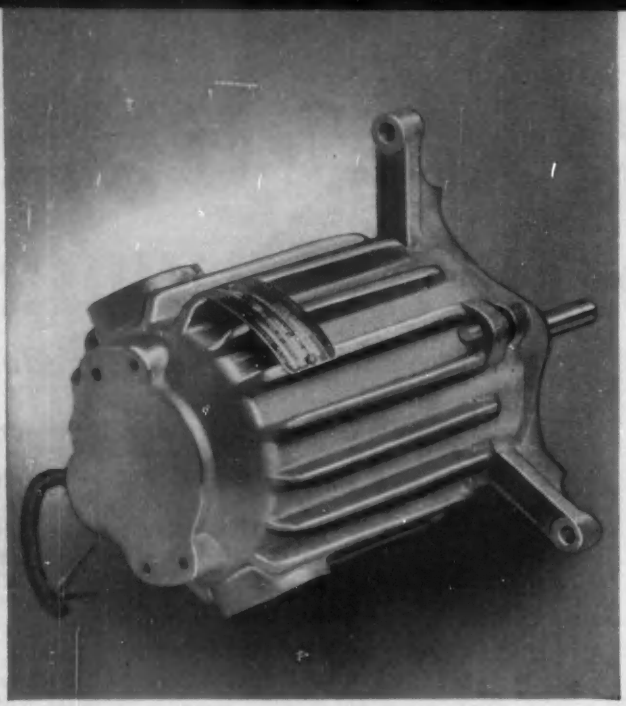
CLEVELAND • YOUNGSTOWN • DAYTON • PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY • BUFFALO • ST. PAUL • GRAND RAPIDS • DETROIT • FLINT • FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE • KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE • DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • TORONTO, CANADA and OTHER AREAS

Miller

MILLER FLUID POWER CO.
(Formerly MILLER MOTOR COMPANY)

2002-04 N. Hawthorne Ave., Melrose Park, Ill.

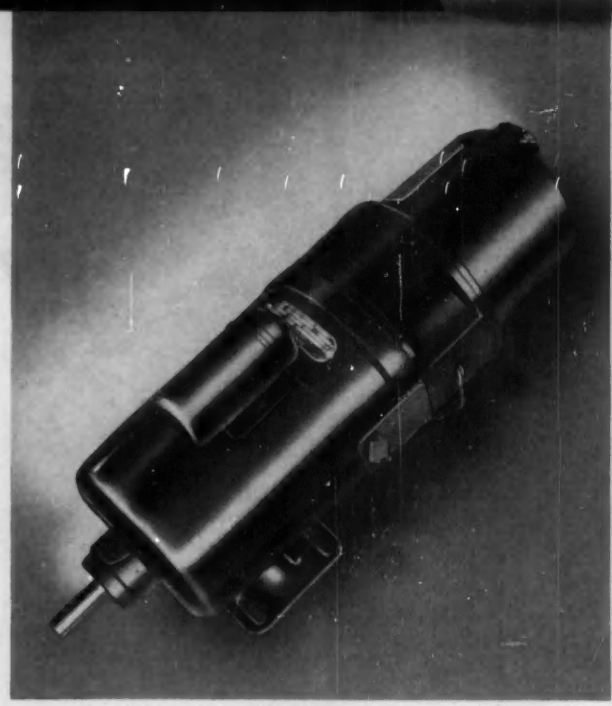
AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS



1. UNIVERSAL MOTOR FOR BLOWER MEETS LIMITED SPACE REQUIREMENTS

General Electric engineers were asked to supply a specially mounted motor for an axial fan. Among the special considerations were a limited amount of space for the motor and need for exceptionally long brush life.

The space problem was solved by G-E engineers with a universal motor designed with a special tripod mounting, extended bearing nose, and a diameter of only $6\frac{1}{16}$ inches. Extensive testing proved this motor to have more than required brush life. This General Electric air-over motor can also be supplied in Class 1, Group D, explosion-proof construction.



2. SPECIAL DC BRAKE MOTOR DESIGNED FOR LOCOMOTIVE DOOR OPENER

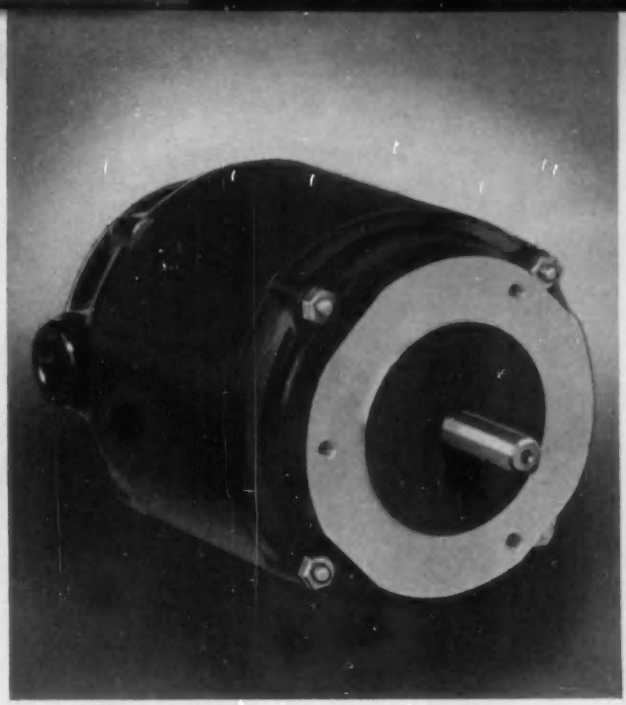
Limited space requirements presented a problem to G-E engineers when they were asked to design and build a motor to open and close a 1200-pound locomotive car door. Another specification: positive starting and stopping action.

A team of General Electric motor experts designed a special space-conserving, side-wall mounted motor to be used with a gear reducer and magnetic brake.

G.E. offers a complete line of d-c motors in the following enclosures: drip-proof, totally enclosed non-ventilated, explosion-proof, severe-duty, navy- and marine-type construction.

These four cases show how you

THIS TEAM OF G-E MOTOR EXPERTS is ready to tackle your special drive problems: (1) Lubrication specialist (2) Mechanical design engineer (3) Vibration specialist (4) Electrical engineer (5) Product design engineer (6) Heat transfer specialist.
1
2
3
4
5
6

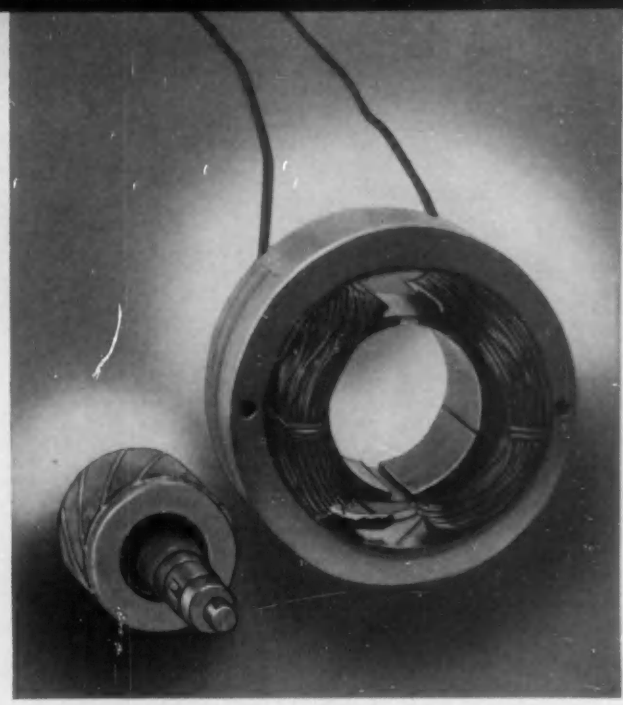


3. SYNCHRONOUS INDUCTOR MOTOR IDEAL FOR LOW-SPEED CAMERA DRIVE

This General Electric customer required a special low-speed motor for an automatic camera drive. Among the customer's specifications was precise starting and stopping action.

Experience indicated that a synchronous inductor motor would be ideal for this low-speed application. The synchronous inductor motor G-E engineers came up with had a rabbet fit for direct mounting to the camera. The motor operates at 75 rpm and a torque of 75 oz-in., and is giving excellent service.

Synchronous inductor motors—a G-E exclusive—are available in 115- and 230-volt ratings 60, 50, and 25 cycles.



4. SHADED-POLE INDUCTION MOTOR TAILORED TO VIBRATING SANDER

An industrial sander manufacturer requested a built-in motor to withstand severe vibrations.

G-E engineers, working closely with customer engineers, helped to develop a hand sander, cool to the touch, by adapting a specially designed shaded-pole motor rotor and stator.

Not only were these shaded-pole motor parts designed to withstand vibrations encountered in application, they also allowed the customer to greatly simplify assembly operations.

G-E shaded-pole motor parts are available in ratings from 15 mhp to 1/12 hp, 115 and 230 volts, 60 and 50 cycle.

solve drive problems when you buy General Electric specialty motors

You buy solutions to your electric drive problems when you buy versatile General Electric specialty motors. These motors, applied by experienced G-E application engineers, can really solve the "tough ones" for you—design problems like those posed above.

Among the specialty motor products available for your application are: d-c motors and generators, shaded-pole motors, specialty induction motors, amplidynes, tachometer generators, low-speed synchronous inductor motors, dynamotors, and universal motors and parts.

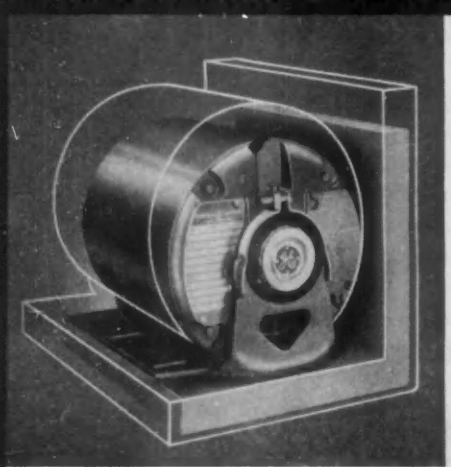
TURN OVER YOUR SPECIAL MOTOR PROBLEMS to General Electric early in your planning by contacting your local G-E Apparatus Sales Office. Or, if you prefer write describing your requirements including quantity and application to Section 704-54, General Electric Company, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

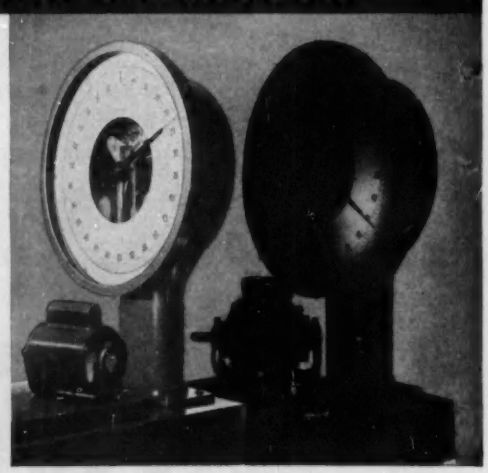
Get proved performance, big savings

SAVE ALL 3 WAYS WITH SMALLER, LIGHTER G-E MOTORS



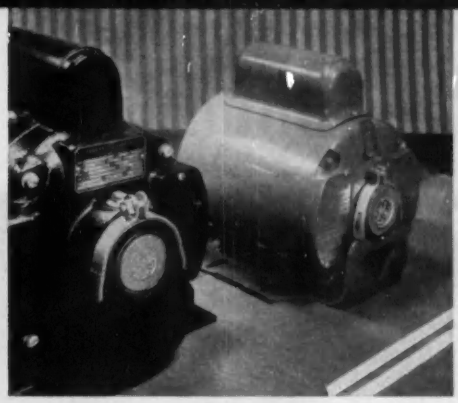
ON MATERIAL—You can design smaller, lighter motor mountings and housings—improve products at same time.

ON ASSEMBLY—Your assembly personnel will produce more efficiently with less fatigue when installing easy-to-handle G-E motors.

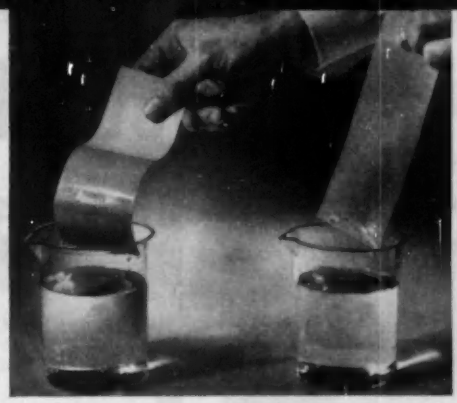


ON TRANSPORTATION—Save up to $1 per unit, depending on size and nature of product and distance shipped.

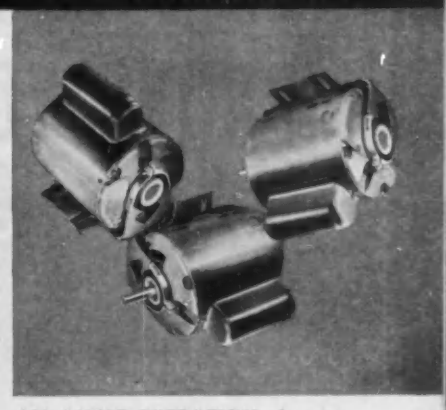
ONLY G.E. OFFERS ALL THESE SUPERIOR FEATURES



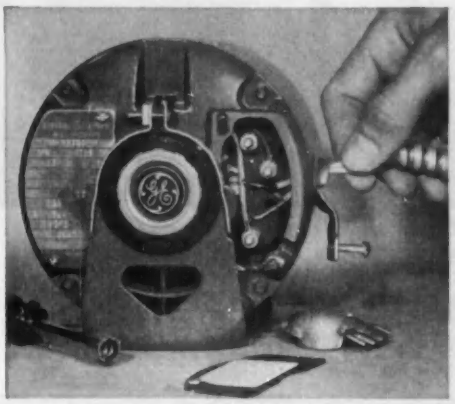
SMALLER, LIGHTER DESIGN—as much as 40% smaller and 50% lighter—saves for you on every step from design to shipping.



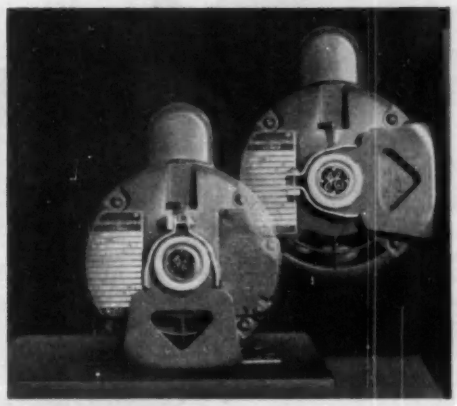
MYLAR* INSULATION (right) has over 35 times the moisture resistance and 8 times the dielectric strength of paper insulation (left).



ALL-ANGLE OPERATION—in any position lubrication is sure and protective; no need for costly specials.



EASY CONNECTION—terminals are close to cover plate; speed-nut welded inside shell permits fast connection from outside.



MOUNTING VERSATILITY—with resilient *or solid* cradle bases, you can rotate *any* motor, or easily remove cradle, to meet design needs.

DOUBLE LUBRICATION LIFE—50% more oil, and efficient oil retention system cut maintenance.

NOW with these advanced G-E motors

3 million in use demonstrate benefits on wide variety of products

Three years ago, General Electric pioneered the smaller, lighter fractional-hp motor. More than 3 million of these advanced G-E motors are now providing outstanding performance on the products of thousands of manufacturers. These manufacturers have realized tremendous savings on material, shipping, and assembly costs.

Today, with these savings encouraging complete conversion to smaller, lighter designs, only the advanced G-E motor provides you all of the superior features listed above. And General Electric offers you high-volume delivery *now* of smaller, lighter fhp motors for every application.

APPLICATION AID—from engineers who have helped thousands of manufacturers improve products with smaller, lighter G-E motors—is available to you. Contact your local G-E Apparatus Sales Office. For more information on advanced G-E fhp motors, write Sect. 702-21, General Electric Co., Schenectady 5, N. Y.

*DuPont trade-mark.

Progress Is Our Most Important Product

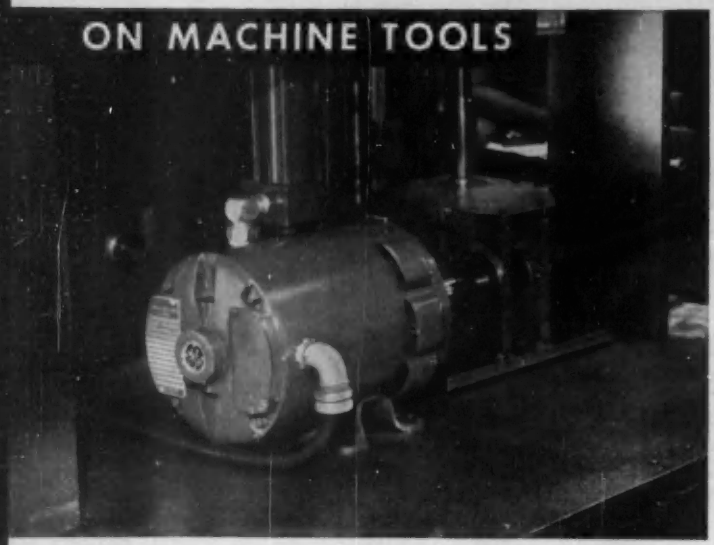
GENERAL ELECTRIC

ON NEXT PAGE
4 examples of G-E motor benefits in action

How advanced G-E fhp motors help

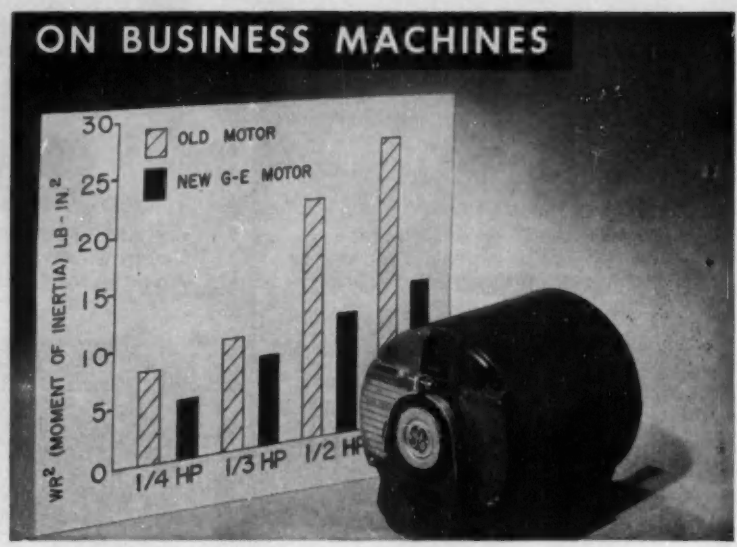
IMPROVE YOUR PRODUCT PERFORMANCE

ON MACHINE TOOLS



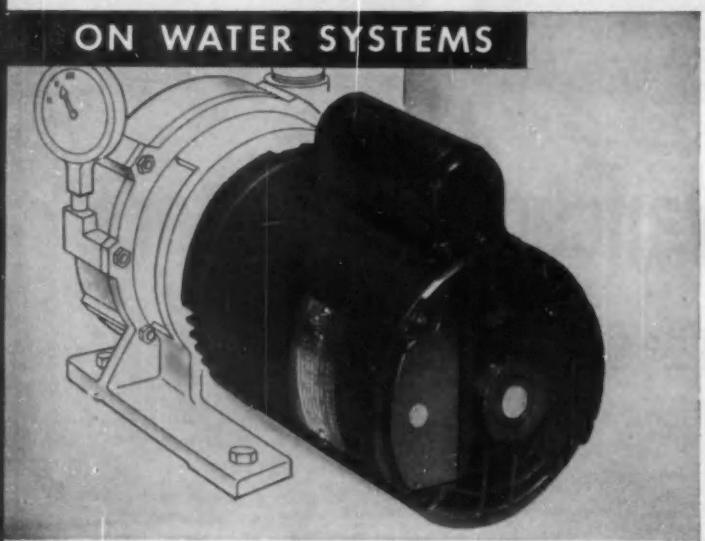
TEN-YEAR FACTORY LUBRICATION of G-E totally enclosed fan-cooled motors means extra-low maintenance. Special ball-bearing construction and new-type grease give long service, support heavy thrust loads. Welded-on base assures rigid mounting; compactness simplifies assembly and design. Rated ¼ to ¾ hp, 3-phase. Write for Bulletin GEC-1306.

ON BUSINESS MACHINES



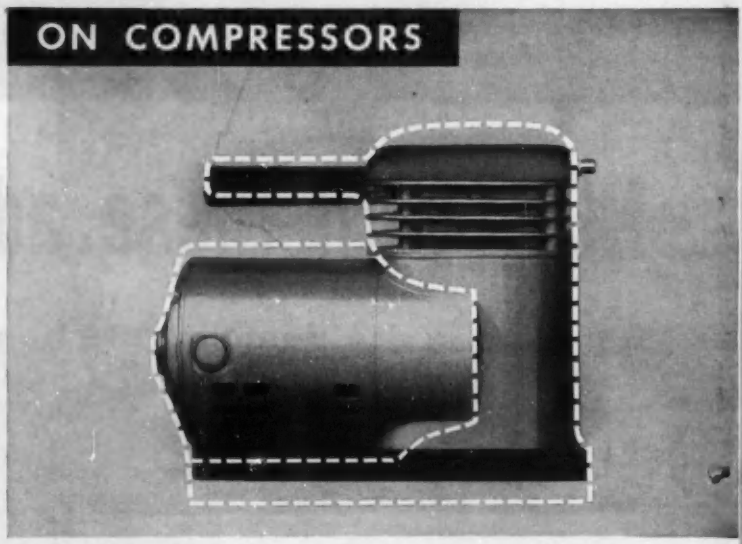
INSTANT MOTOR REACTION due to the low-inertia rotor makes smaller G-E fhp motors ideal for start-stop business-machine use. Absence of high-pitch noise in the magnetic circuit and vibration deadening effect of resilient mounting mean extra-quiet operation. Available in split-phase (Bulletin GEC-859) and capacitor-start (GEC-857) ratings from ⅙ to ¾ hp.

ON WATER SYSTEMS



EXTRA MOISTURE RESISTANCE is provided by modern insulation in this G-E jet-pump motor. Special under-water tests by G-E engineers prove Mylar* slot and between-phase insulation 35 times better than paper. New grease lasts 10 years, minimizes maintenance in hard-to-reach places. Ratings: ¼ to 1½ hp, vertical or horizontal mounting. Bulletin GEA-5902.

ON COMPRESSORS



SMALLER SIZE of G-E fhp motors for compressors enables you to design more compact products. 40% lighter weight cuts your shipping costs. Two frame sizes cover entire line, permit you to standardize tooling, cut pulley stocks. A complete line of general-purpose and special-service ratings from ⅙ to ¾ hp is available. Bulletins GEC-854 and GEC-857.

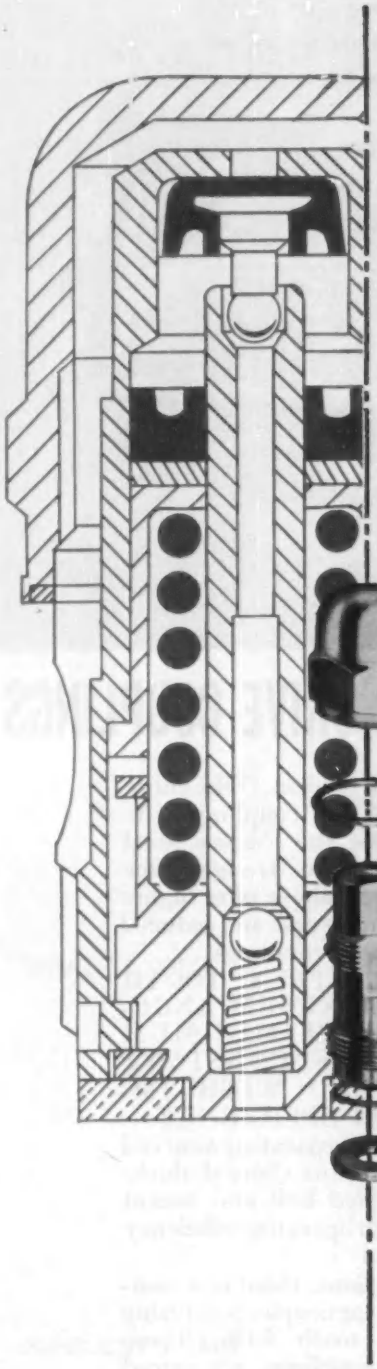
FOR FULL INFORMATION on these and other G-E fhp motors, contact your nearby G-E Apparatus Sales Office. And write for Bulletins listed to General Electric Co., Sect. 702-21, Schenectady, N. Y.

GENERAL ELECTRIC

calls lubrication shots for hidden bearings!

ALEMITE Accumeter®

Insert valves in manifold blocks assure fool-proof automatic lubrication for closely grouped bearings

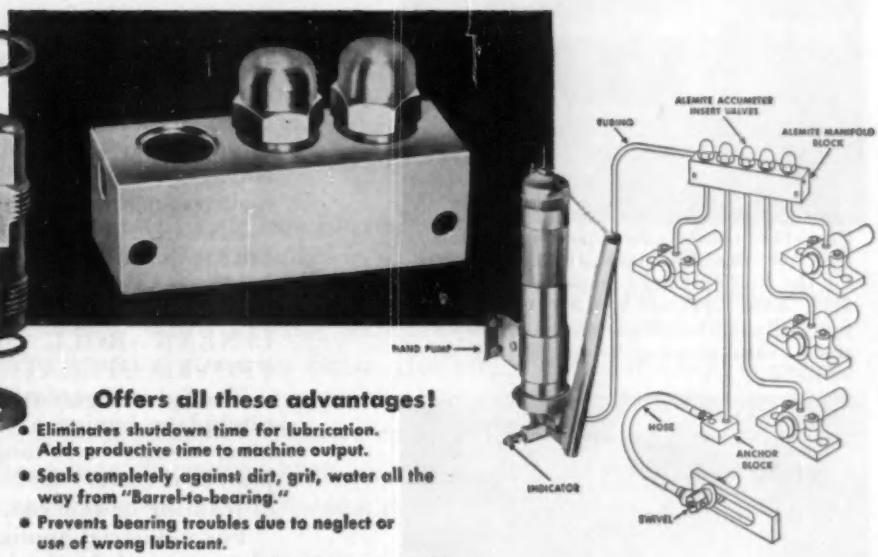


Ever have the problem of planning lubrication for a group of bearings in cramped quarters? Especially when you wanted all the advantages of centralized lubrication over slow hand methods—yet there wasn't even room for conventional centralized valves at the bearings? A tough problem in lubrication easily solved with Alemite Accumeter insert valves in an Alemite manifold block that can be mounted wherever convenient.

Alemite manifold blocks hold 3, 4, 5, or 10 valves that meter the exact amount of lubricant needed, route it through tubing, require minimum space at bearing. There is no chance of overlooked bearings, no chance of overlubrication.

All this can be manually operated or fully automatic. No downtime—and each bearing gets a full film of lubricant—*because lubrication goes on while the machine is in operation!* No wonder 95% of major plants buying machine tools specify centralized lubrication.

And any Alemite Accumeter system is simple to design into any machine. Economical, too. And there is a system to exactly solve any machine lubrication problem. See for yourself the savings and efficiency they provide. Find out about these automatic systems now, and you, too, will specify an automatic Alemite Accumeter system.



Offers all these advantages!

- Eliminates shutdown time for lubrication. Adds productive time to machine output.
- Seals completely against dirt, grit, water all the way from "Barrel-to-bearing."
- Prevents bearing troubles due to neglect or use of wrong lubricant.
- Services all bearings—including those inaccessible or dangerous—in one operation.
- Avoids work spoilage and bearing repairs due to overlubrication.

Factory tested—field proved

Exhaustive, in-the-field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—equal to 122 years of *twice-a-day service!*

ALEMITE

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ALEMITE ACCUMETER CATALOG

FREE!

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Please send me my free copy of the Alemite Accumeter Catalog.

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Company .....

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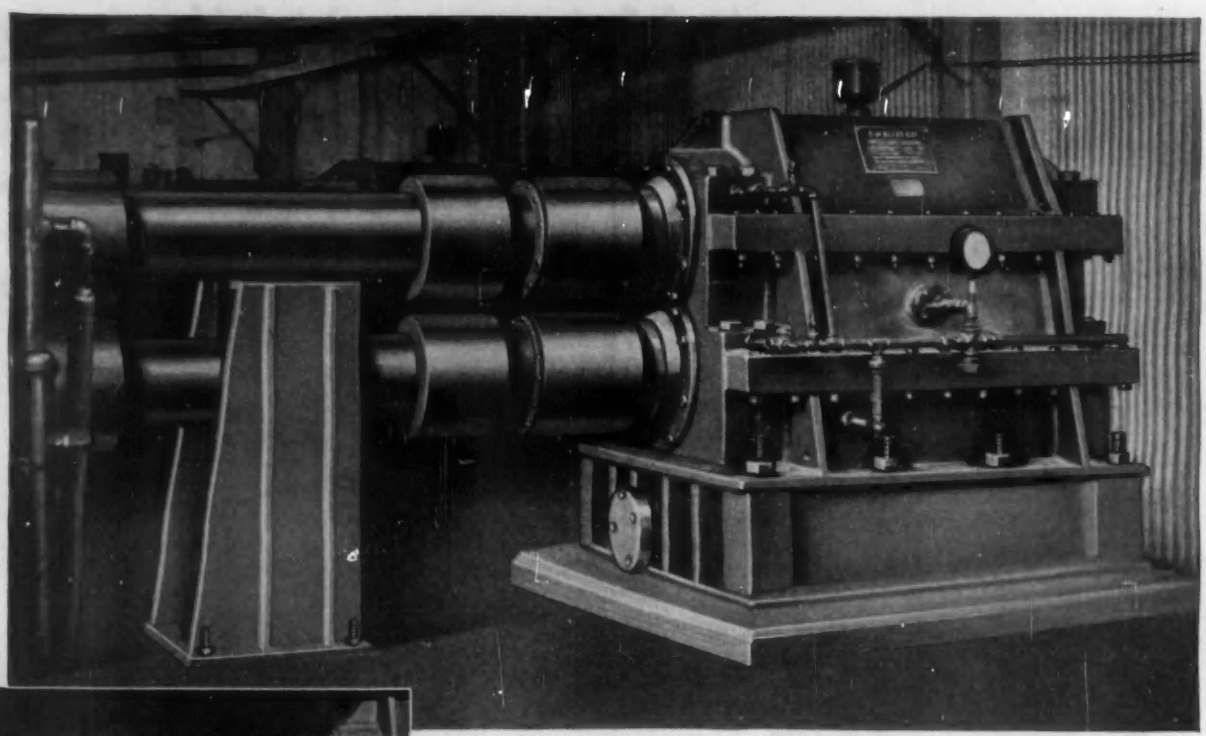
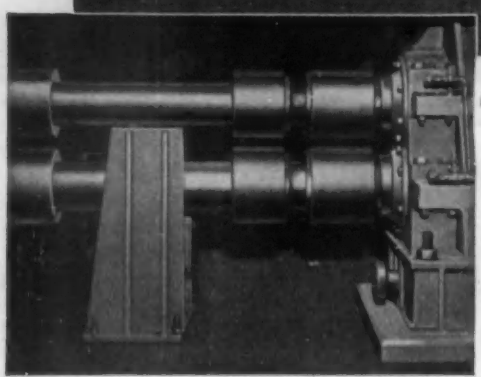
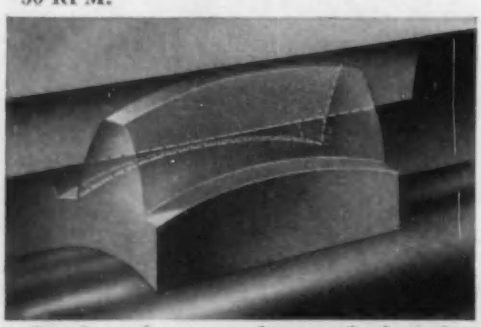




Four stand tandem cold reduction mill built by E. W. Bliss Company, of Salem, Ohio, for the Empire Steel Company, of Mansfield, Ohio. Equipped with eight "Sphereflex" roll shaft couplings, two couplings per stand, each coupling rated 750 HP at 50 RPM.



Cut above shows curved root and spherical tooth flank, which will compensate for any and all types of misalignment.

"SPHEREFLEX" ROLL DRIVE COUPLINGS

The E. W. Bliss Company, Salem, Ohio, chose the "Sphereflex" spindle roll coupling in its design of a 4-Hi mill for the Empire Steel Company of Mansfield, Ohio. Designed for 6° angularity the couplings above offer higher efficiency, lower replacement cost and reduced maintenance than old style couplings.

EXCLUSIVE "SPHEREFLEX" TOOTH DESIGN PERMITS MAXIMUM ANGULAR CAPACITY WITH MINIMUM BACKLASH — PERMITS CONSTANT LINEAR ROLL SPEED WITH IMPROVED OPERATING EFFICIENCY.

The Sphereflex tooth, incorporating a curved pitchplane having a constant chordal thickness, results in a modified ball and socket joint so necessary for high operating efficiency of rotating equipment.

For industrial applications, there is a complete range of standard gear couplings utilizing the new "Sphereflex" tooth form. These standard "Sphereflex" couplings are priced competitively with ordinary commercial gear couplings.

Let Phillie Gear help you design greater efficiency and life into your industrial equipment.

SEND FOR "SPHEREFLEX" CATALOG C-540, AND BE CONVINCED.

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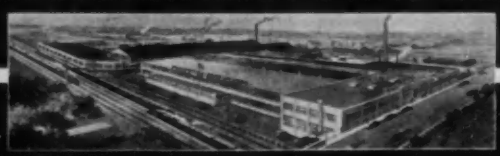


Industrial Gears & Speed Reducers

LimiTorque Valve Controls

Established 1892

Perspectives

IN DESIGN AND DEVELOPMENT

STOCKING TOOLS

Just last month the House Appropriations Committee gave its stamp of approval to the Defense Department's $100-million reserve tool program for fiscal 1956. At the same time, the committee voted to keep on the books any of the fiscal 1955 money (another $100-million) not spent by July 1956. The Pentagon told the committee that this unspent fund will amount to about $48-million. This is only the beginning, for if plans proceed as Defense Department officials would like, the program will go for another three years at $100-million per year until $500-million has been spent for machine tools that will be stored for use in a future war. While this was the primary objective of the plan, running a close second was the desire to help fill the coffers of the machine tool builders, and keep the industry in top shape to permit quick expansion.

This plan goes back a few years—to the Truman administration, in fact—when it was known as the Vance plan. Studebaker Corp. president Harold S. Vance, then head of a government advisory committee, suggested a program that would avoid the machine tool bottlenecks that slowed down the World War II and Korean production schedules. The crux of the Vance proposal was that the military should estimate long-range industrial mobilization requirements, buy the plant and equipment necessary, then keep this productive capacity up to date and in standby shape.

WHAT TO BUY?

A request for $500-million for reserve tools and facilities was added to the fiscal 1954 budget then being set up. This fund was not part of the regular funds to the individual services for current plant and equipment requirements. When Defense Secretary Wilson took over, he said that the reserve tool plan was too costly. However, the fund was kept in. Later, when Congress was working on the budget, the fund was cut to $250-million, on the basis of Wilson's coolness to the plan. (Since then, his feelings have changed.) Even so, in the next year not a penny of this amount was spent, mainly because the Defense Department did not know what to buy.

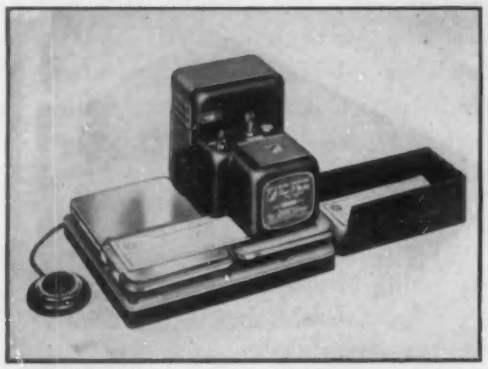
FUND CUT AGAIN

Then, last year, when Defense Department officials went before Congress to present their appropriation request for fiscal 1955, they asked that the $250-million reserve tool fund be kept on the books. The House eliminated the fund completely, because the Defense Department officials still could not come up with an intelligent plan for spending the money. Also, the point was made that there still existed about $1.6-billion of a fund given to the services at the time of Korea to supply weapons producers with plant and equipment. So, why not combine the $250-million reserve tool money into one big checking account. Backers of the reserve tool program did not go along with this, feeling that it destroyed the intent of the original plan.

(Continued on page 125)

Why Bodine motors were selected for Hedman Check Writers

1 This is a Hedman Check Protector. It imprints the amount of your check...in indelible ink; then shreds it into the paper.



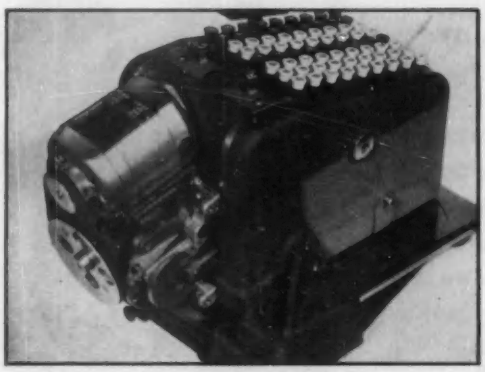
2 This is a Hedman Sign-O-Meter and Dater. It signs and dates checks ten times faster than you can do it by hand.

3 You can use the two units singly or together as shown above. Three separate locks prevent unauthorized use of signer. Forgers are completely thwarted.

BODINE MANUFACTURES FRACTIONAL HORSEPOWER ELECTRIC MOTORS FOR:

dictating machines
electric typewriters
revolving signs
adding machines
coin counters
therapeutical equipment
film projectors
printing timers
automatic dispensers
electronic controls
stapling machines
tape dispensers
automatic wrappers
compressors
check signers
recorders
type setting machines
display units

...and for many other applications.



4 Here's the Bodine Type VCF-12 motor used in the Check Protector. The same motor is also used in the Sign-O-Meter and Dater.

5 This is Mr. C. W. Johnson, Vice President of the Hedman Company, manufacturers of both machines.

"For over 35 years, we have used Bodine motors. We require motors that are small in size, sturdily constructed, long lasting, trouble-free and quiet in operation. Nonetheless, they have to supply the necessary high torque needed. In addition, we have always found Bodine engineers very cooperative in helping us with our motor problems."

6 And here, Mr. Johnson tells of his experience with Bodine Fractional Horsepower Electric Motors...see above.

BODINE

50th Anniversary

BODINE

fractional / horsepower

MOTORS

7 Be sure your motor is as good as your product. For information contact Bodine Electric Company, 2260 W. Ohio St., Chicago 12, Ill.

Ask for a sample copy of "The Motorgram," a bi-monthly publication discussing application and design of fractional horsepower electric motors.

DOWN TO $100-MILLION

Getting back to the elusive $250-million, by the time the appropriations bill reached the Senate for action, Pentagon officials had put together some semblance of a plan for spending the money, and were returned $100-million of their yearly allowance. During the many discussions, it was learned that this fund was not for new tools alone, but also for such items as new special dehumidified warehouses to store machine tools not in use as a result of last year's and future defense cutbacks. The chances are that the long lead-time tools purchased in the reserve tool program will be stored in these warehouses, although a spokesman at the Pentagon said that the tools probably will be stored by the companies making them, or by the company which eventually will use them for a project or projects still on the drawing boards.

FOREIGN MACHINE TOOLS OUT

Because the plan was designed to prop up the U. S. machine tool industry, foreign manufacturers will get little business. To date, the only planned expenditure for tools outside the U. S. is for $4-million worth of Swiss precision tools for a project involving proximity fuses. A big importer of foreign tools plans to approach government officials with the idea of buying foreign machine tools and paying the manufacturer in surplus commodities like wheat, butter, or cotton. This idea, not a new one, will not only take a load off the taxpayer, but will get equipment which the services cannot get now because of limited budgets.

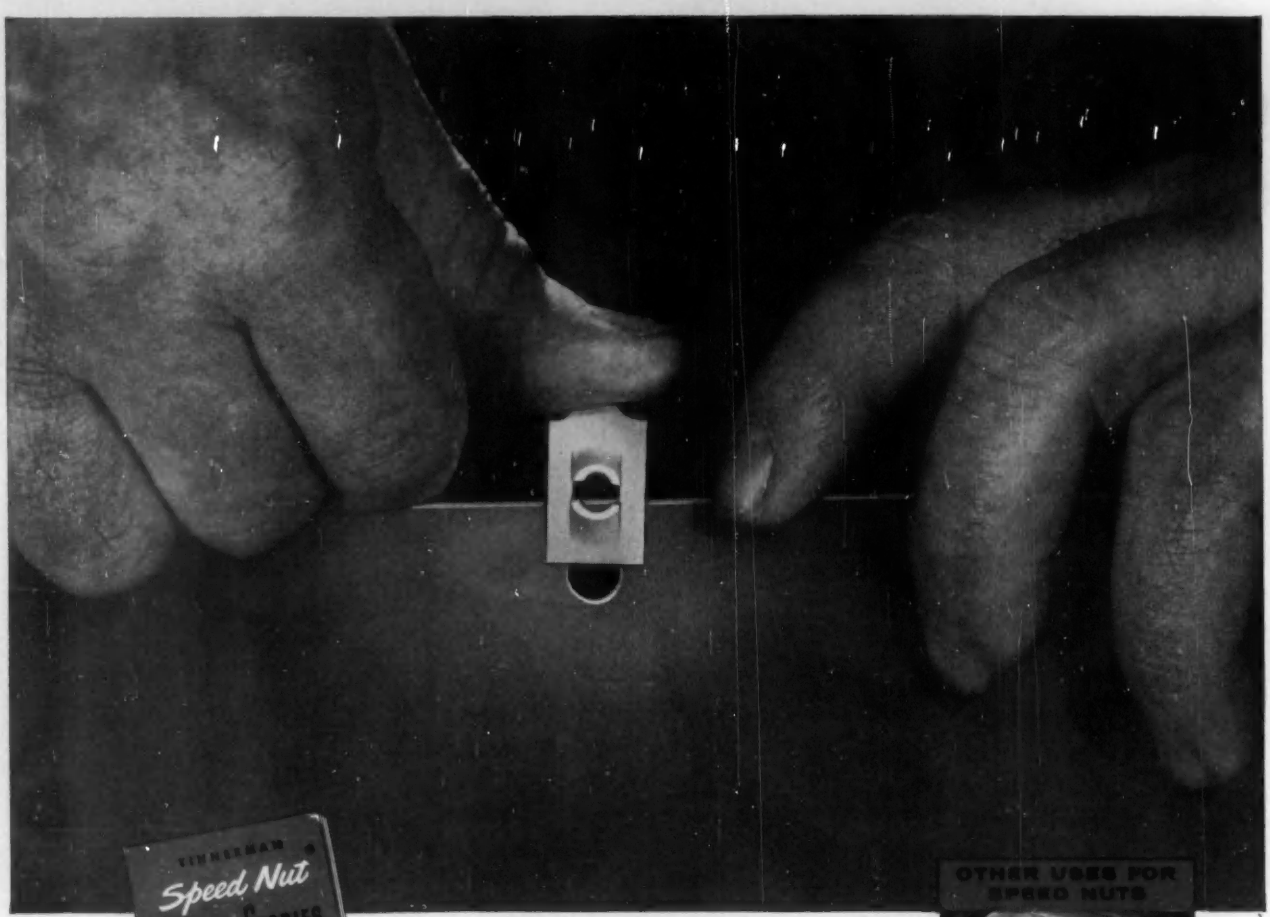
LONG LEAD-TIME TOOLS ONLY

Some of these machines will cost as much as $1-million apiece, with delivery time on each running from one to two years. According to plans, tools purchased with funds from fiscal year 1955 (ending July 1st) average over $50,000 per tool. In his appearance before the Senate Appropriations Committee, Thomas P. Pike, Assistant Secretary of Defense for Supply and Logistics, said, "None of the fiscal year 1956 money will be used to purchase shelf items, but only critical tools with long production time. Also, none of this money is being spent for the development of new prototype tools, or any jigs or fixtures. The services are making a special effort to include in this program tools which are adaptable for producing not only end items of current design, but also end items of improved design which are now in the design and testing stage."

PRESENT SETUP

The present reserve tools program stands like this: Of the $100-million allocated for fiscal year 1955, the Air Force was given $84.6-million. Of this amount, $40-million has been set aside for reserve tools for airframe makers, $38-million for engine builders, and $6-million for strut manufacturers. So far, none of the funds has been obligated, but Air Force officials say that $40-million will have been obligated by July 1, 1955, and the remaining $44-million by Jan. 1956.

The Navy was given $14.2-million. Of this, $6.3-million was set aside for reserve tools for ordnance and related manufacturers, $5.5-million for aircraft, and $2.4-million for shipbuilding. So far $9.7-million has been obligated, with the rest allocated by Jan. 1956. The Army was given $1,074,934, which has been committed.



TINNERMAN Speed Nut SAVINGS STORIES

Thumb Replaces Spot Welder with Tinnerman SPEED NUTS!

Here is a typical assembly-line scene . . . a Tinnerman "J" type SPEED NUT being applied to a panel where a weld-type fastener was formerly used. That's the way to cut assembly costs—by saving precious man-hours and eliminating the need for special skills, tooling and equipment!

This one-piece, self-locking, spring steel SPEED NUT brand fastener not only makes welding unnecessary, but it also eliminates clinching, staking, tapping, and costly threaded inserts. It snaps in place by hand quickly, easily, and provides a heavy-duty vibration-proof attachment. Self-retained in screw-receiving position, it is ideal for blind-location assembly.

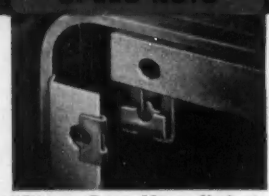
"J" type SPEED NUTS are available for a full range of screw sizes and panel thicknesses. In all, there are more than 8000 variations of SPEED NUT brand fasteners to help you reduce assembly costs. See your Tinnerman representative soon . . . and write for your copy of SPEED NUT "Savings Stories."

TINNERMAN PRODUCTS, INC. • BOX 6688, DEPT. 12, CLEVELAND 1, OHIO

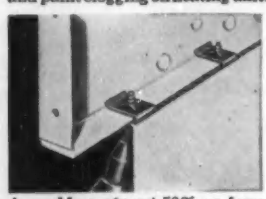
Canada: Dominion Fasteners, Limited, Hamilton, Ontario. *Great Britain:* Simmonds Aerocessories, Limited, Treforest, Wales. *France:* Aerocessoires Simmonds, S. A., 7 rue Henri Barbusse, Levallois (Seine). *Germany:* Hans Sickinger GmbH "MECANO", Lemgo-i-Lippe.

TINNERMAN Speed Nuts® FASTEST THING IN FASTENINGS®

OTHER USES FOR SPEED NUTS



"J" type SPEED NUTS eliminate problems of hole misalignment and paint clogging on heating unit.



Assembly costs cut 50% on farm equipment with "J" type SPEED NUTS.

"J" type SPEED NUTS help plastic sign maker save 48% in assembly costs.

More than 8000 shapes and sizes

Yardsticks of Perfection

ONE OF THE MOST IMPORTANT DECISIONS in engineering design is the answer to the question, "Is it good enough, too good or not good enough?" If the design is too good or not good enough, the company will have little or no profit. The results may even be disastrous. Only the designs that are good enough but not too good will bring prosperity to the company. But what are the yardsticks by which the qualities of a product can be measured?

Unfortunately there are no yardsticks by which we can measure definitely the degree of perfection of a given design as a commercial product. Even after the product has become a proven success it is often impossible to evaluate correctly the reasons for its popularity and saleability.

When a product has become a highly profitable item it is only natural that sales and sales promotion should claim, and be given, some of the credit. And of course production deserves commendation for low cost of manufacture. Engineering design is also entitled to recognition and often should be given more. How much should go to each of these three will be different for almost every product. Actually the distribution of credit is relatively unimportant. The only really important fact to determine is what made it a success.

Buying will always be largely emotional, especially in the field of consumer goods. Hence good advertising and hard selling will always swell the sales record. But smart selling has never placated the disgruntled purchaser who found that the machine he bought was poor in design or workmanship. Ironically, it is easier to find out why a product does not sell than it is to discover its merits and sales values. A person will rave about the wonderful new car he bought. But if he is called upon to state explicitly the unique merits of his purchase he will be unable to do so. His answer will most likely be generalities or vague claims. He may even attribute to his new car features of design that it does not possess.

Evaluation of perfection of design will always be a matter of intelligent judgment based upon an intimate knowledge of the value of design features and the ability "to feel the pulse" of prospective buyers.

It is extremely difficult to find out how much value the prospective buyer attaches to a given feature in an existing product. To determine in advance what the demand will be for a new product or feature is almost impossible. There can be no vocal demand for a product that does not exist. On the other hand, the man who invented and developed the product has a far better factual basis for estimating its values, but unfortunately he is likely to highly over-rate its sales possibilities.

There are no yardsticks of perfection and it will always be extremely difficult to evaluate the market possibilities of either existent or nonexistent products. The only sure method of determining the demand for a new product or new design features is to make samples and offer them for sale.

George F. Podenhall

NEW **DEPARTURES OF TOMORROW**

Versatile, easy-to-operate machines that take the backache out of "ironing day" are a housewife's dream come true. And manufacturer after manufacturer has called on New Departure for its ball bearings.

It could well be that in less than a decade a compact new appliance for the home will clean and press a suit, coat or dress in seconds.

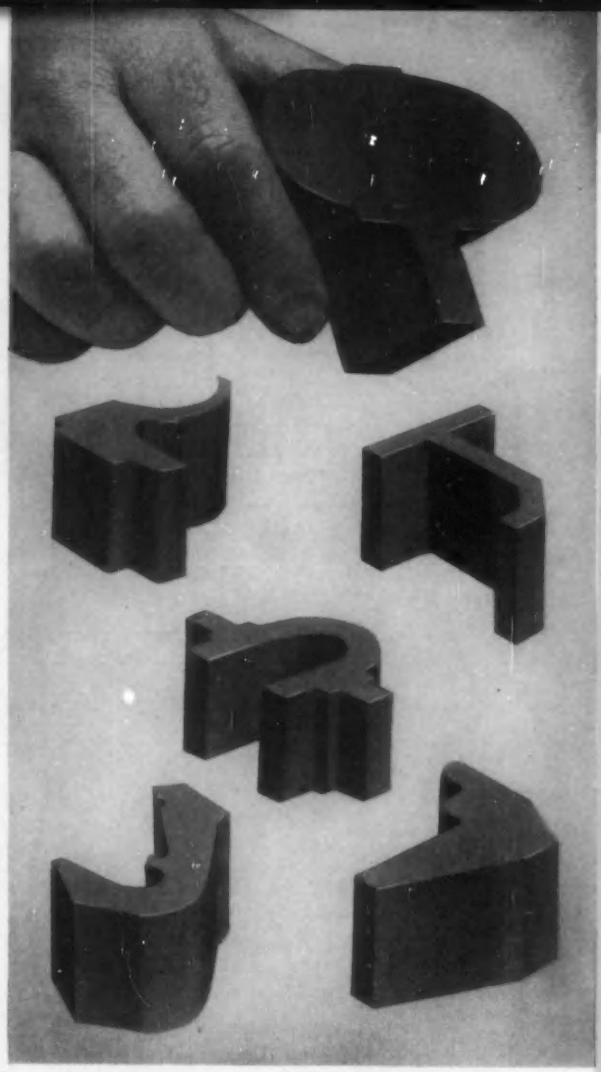
Of course, such a machine is yet to be developed. But one solid fact: when the "Valet-mat" does arrive, it will probably be New Departure ball bearings that keep it operating smoothly and efficiently.

Today, practically any type of home-service product you can name is New Departure-equipped. So, when your thoughts turn to new departures of tomorrow . . . think of New Departure—the company that makes the great forward strides in ball bearing design and manufacturing.

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

NEW DEPARTURE
BALL BEARINGS

NOTHING ROLLS LIKE A BALL



HOT EXTRUSION PROCESS produces rollable sections in small quantities at reasonable cost, and complex or special shapes that cannot be rolled at all.

Extruded Low Carbon STEELS

Hydraulic presses (see cover picture) extrude glass-coated billets through low-cost dies producing complex sections with final dimensions equal to AISI cold finished bar tolerances. These are available now for volume or experimental applications. Current size limitations, typical applications, and properties obtainable are discussed.

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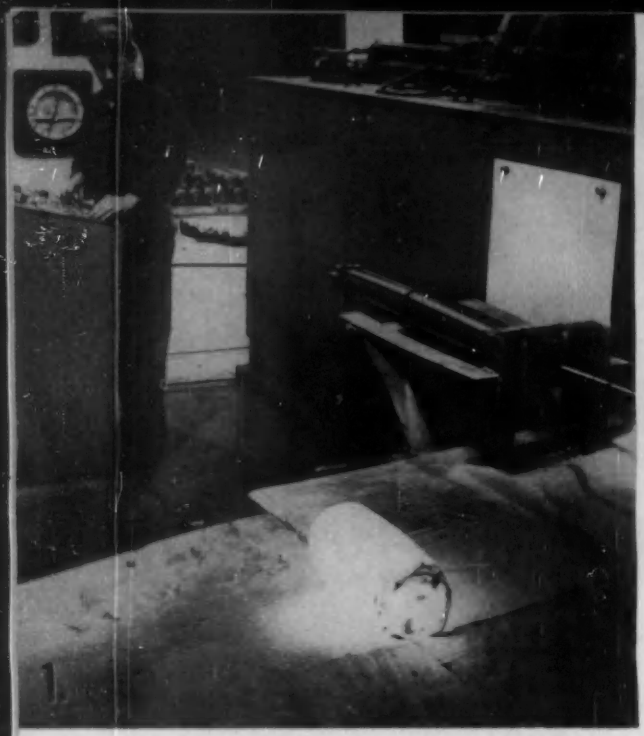
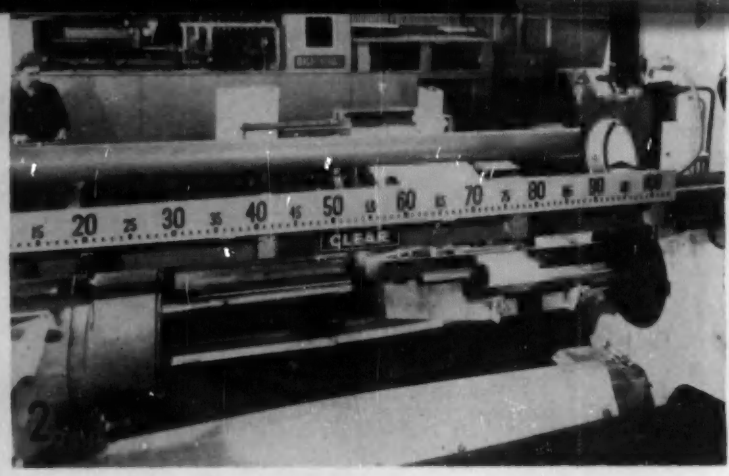
LOW CARBON STEEL SECTIONS are now available in extruded forms. These include any standard AISI carbon steel grade such as C1015, C1018, C1020, and C1050. The hot extrusion of high alloy grades of steel is now fairly common practice but extruded low carbon steel sections have not been available in commercial quantities heretofore.

Economic and Production Advantages

The development of low carbon steel extrusion makes possible the short run production of rollable sections. The cost of an extrusion die is a very small portion of the cost of a set of rolls. Setting up an extrusion die is a much simpler operation than changing a set of rolls thereby effecting operating economies in time and labor. The result of these overall savings permits the consideration of extruded low carbon steels for pilot assemblies, experimental, and prototype work.

The hot extrusion process makes possible the production of hollow and solid unbalanced sections which often are so complex that they cannot be rolled. In this connection two or more parts now produced by other methods may be combined into





1. A five-inch billet, weighing about 50 pounds and heated to 2300 F, rolls through powdered glass to the extrusion press. The glass acts as a lubricant during the actual extruding process. The heating furnace at the right is an induction unit which brings the billets from room temperature to extrusion temperature in about 1 minute.

2. The 1,000-ton horizontal extrusion press at Jones & Laughlin Steel Corporation, Pittsburgh, showing ram (left) moving left to right toward the white hot billet. The glass-coated billet will be squeezed through a die producing the extruded section. Numerals

a single extruded section and eliminate a joining or fastening operation with savings in material as well as other inherent economies.

Development of Steel Extrusion Process

The hot extrusion of steel depended upon the discovery of a suitable lubricant which would permit use of this fabrication process for ferrous alloys. There were two important problems which had to be solved before hot steel extrusions could be produced on a commercial basis. These were the development of lubricants which could be used between the billet and the extrusion press container and between the billet and the die.

Lubricants of mineral origin and those produced from animal and vegetable raw materials were found to be inadequate for the operating temperatures required for the hot extrusion of steels. Materials containing carbon, instead of lubricating, were found to increase the seizing of the billet and the tools. These failures led to the discovery that glass, introduced in granulated form, served as a lubricant and an insulator which effectively protected the extrusion press tools from contact with the billet and increased die life.

Description of Low Carbon Steel Extrusion

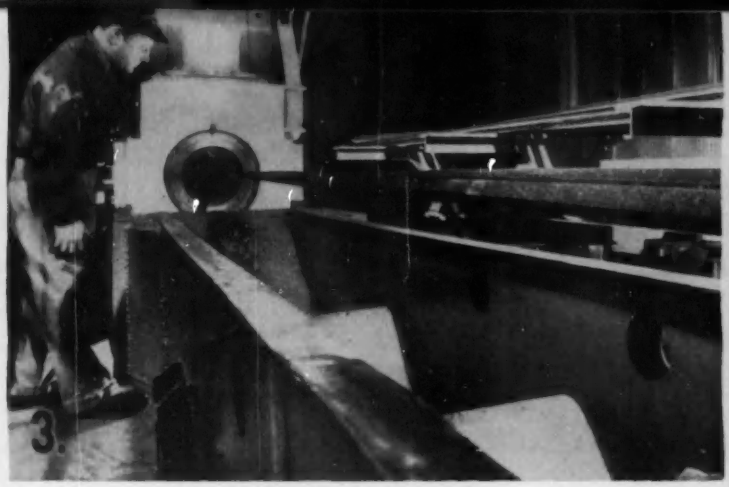
The raw material for this operation is produced as hot stock in rounds of 4 in. and 5 in. diameters. This stock is machine straightened and cut to length. Billet lengths vary from 6 in. to 20 in. depending upon the length required for the finished extruded section. The billets, sometimes called slugs, have a chamfer turned on one end and over a ¾ in. radius so that they may have easy entrance into the die.

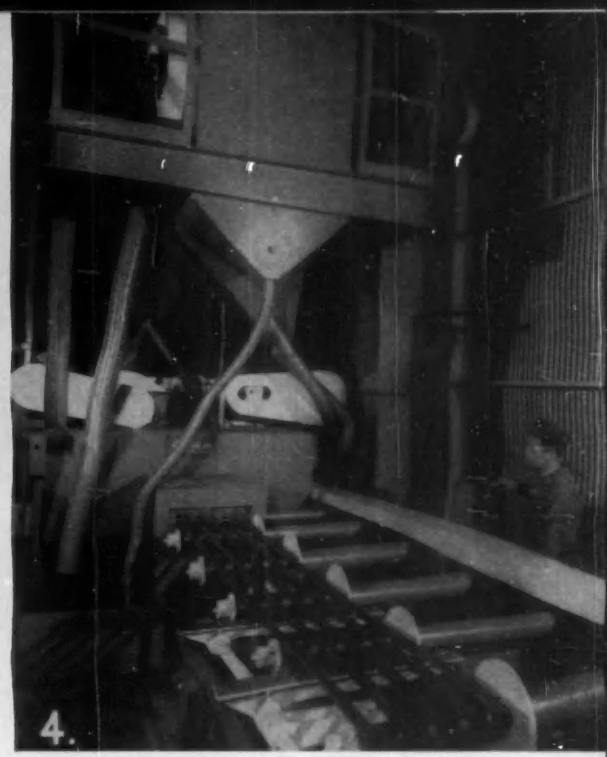
The slug then moves into an automatic induction furnace preheating coil where it is brought up to 1750 F. After preheating, the slug is shifted to a high temperature coil where it is brought up to the extruding temperature of 2350 F. This is a continuous operation accommodating 2 to 6 slugs, depending on length, and the entire heating cycle from cold billet to extrusion temperature takes 60 seconds.

The slug is ejected from the heater which stands at a higher elevation than the extrusion press center line so that it may roll down an inclined plane to the press billet loader. The inclined plane is covered with powdered glass which is made plastic by the heat of the billet and fuses to its periphery. By the time the billet reaches the loader it is completely coated with glass. The billet is charged into the press simultaneously with a backer disc sometimes called a dummy block. The dummy block is used to protect the stem of the extrusion press and prevent the negative effects of having this tool come in contact with the hot slug. The dummy block which fits the container more closely than the stem also prevents backward extrusion of the hot metal.

Before extrusion begins, a powdered glass disc is placed between the forward end of the slug and the extrusion die. In this manner, the entire slug is separated from the press container and die by a predetermined thickness of glass. When the die is wedged into place to prevent flow of the metal through any opening between the container and the die, extrusion is ready to begin.

The extrusion press main ram moves forward under 1000 tons pressure and forces the slug to flow through the die opening. The extrusion of low carbon steels is very fast and even though the extrusion time is a matter of seconds, the die is subjected to intensive frictional forces which, coupled with the high temperatures involved, tend to shorten die life. The glass lubrication helps to extend this life and the use of a rotating system further aids in making the extrusion of low carbon steels a practical consideration. The die and dummy block are ejected from the press at the end of each extrusion and air cleaned. Depending upon the quantity of extrusions scheduled, 1 to 12 sets of dies and dummy blocks may be used to maintain maximum production. On orders involving only a few extruded lengths, only one set is required.





on the rule, calibrated in inches, indicate ram travel. The induction heating furnace is shown in the background.

3. After extruding, the section is pulled and twisted to take out the kinks and twists.

4. In this shot blasting machine, the straightened extrusions are cleaned and given a matte finish preparatory to final cold drawing which will give them their finished dimensions. The machine processes the extrusions five at a time.

The extrusion on leaving the press rides on a tilting run-out table which unloads onto a conventional hot cooling bed which transfers it to the straightening, detwisting and shearing equipment. The extrusion process is compressive and the residual stresses induced in an extruded shape cause it to twist and bend. These are not defects as the section may be detwisted and stretched to straightness on the stretcher-detwister straightener machine. This working of the material has a tendency to loosen scale as well as the glass deposits which still adhere to the surface.

When the bar is uniform and straight, it is cut to length and passed through a wheel-a-brator to remove all loosened scale and glass. The resulting product has a smooth, dull, silvery appearance with a slight open surface and has no resemblance to a hot rolled product. These extrusions may now be cold finished.

Uses for Low Carbon Steel Extrusions

The extrusion of low carbon steels make it possible to consider at this time, sections of intricate design which can be contained within a 3 in. dia circle with a weight per foot range from 0.4 lb. to 12 lbs. per ft. It is possible to replace many parts now being made from castings and forgings, or machined to an intricate cross-section from solid bar stock by using steel extrusions. It is not expected that the extrusion process will replace rolling where large tonnages of regular shapes are required.

Despite the short time that low carbon steel extrusions have been available, a number of typical applications have been explored and developed. In the manufacture of business machines, typical uses for extruded sections include transfer levers, typewriter carriage rails, shift carriage levers, carriage stop levers, latch pins, magnet cores and panel board frames.

Electrical equipment manufacturers can use extruded sections for such parts as pole pieces, rotors, pinions, pole wedge sections and housing clamp sections. The machine tool and specialty tool manufacturers have selected such typical applications for extruded low carbon steels as cutter blades, cutter holders, special rails, fixture components, special cams and levers and clamps.

Rotors, pump vanes, impeller blades, holding frames, and locking bars are some of the applications for extruded low carbon steels found in air conditioning equipment and compressors. Even small arms manufacturers can take advantage of the extrusion process for the production of such parts as triggers, trigger guards, firing link pins and back-up plates. Gun sight manufacturers find that gun sight barrel mounts and peep sight frames are good applications for extruded low carbon steel sections.

An excellent field for application of this new form of an old material is the automotive industry. Some of the best applications for extruded low carbon steel can be found in automatic window regulator cams, levers, link couplers, gear shift guide bars, and nose pieces.

While there are a number of potential applications for the relatively long sections produced by extrusion, the farm machinery and equipment manufacturers offer a good field for this type part in such applications as special tie bars, actuating cams, sorter links, drive couplings, pick-off fingers and pinions.

Properties of Extruded Low Carbon Steels

These steels can be extruded to close finish dimensions, thus reducing the amount of finished machining required for the part. In most cases, extruded low carbon steel can be cold drawn to finished dimensions, eliminating the machining step entirely. The process of hot extrusion and cold drawing tends to improve the physical properties of the material and surface finish of the extruded part does not require any subsequent mechanical cleaning.

Standard cold finished bar tolerances in accordance with the AISI manual are obtained by this method. Low carbon steel extruded and drawn sections have thermal treatment properties similar to any cold drawn bar.

HYDRAULIC PUMPS

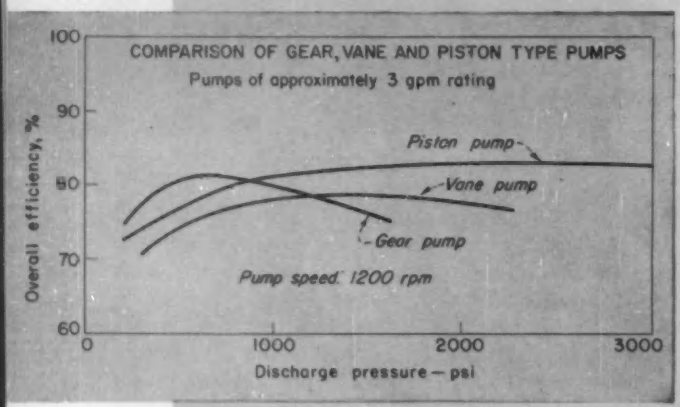
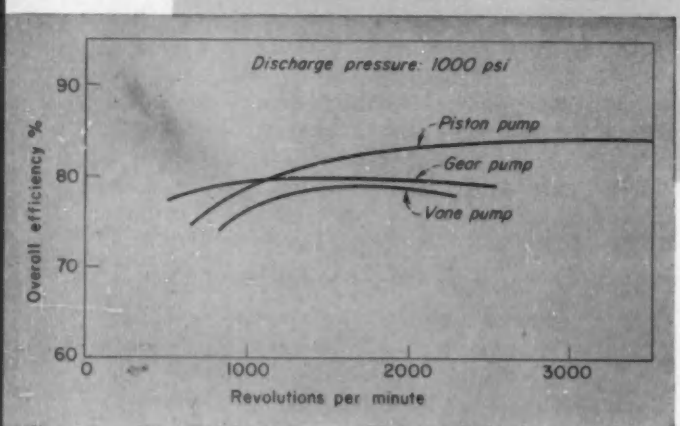


Fig. 1—Sample test data indicating relative efficiency of piston, gear and vane pumps. Note better performance of the piston pump at higher pressures and speeds; the sharp rise in efficiency (curve at left) is due to the reduction in leakage as the speed increases.



Piston pumps are solving new problems in high pressure, high temperature, high speed applications. Minimized leakage is the main requirement in high pressure pumps; piston pumps with smallest clearances are best able to minimize the volumetric losses.

Variable delivery may be provided in either piston or vane pumps, but fixed displacement vane pumps have double the flow capacity and higher efficiencies than variable displacement vane pumps. Special attention must be given in design to minimize hydraulic unbalance on the vanes, cam rings, and rotor bearings.

Gear pumps are fixed displacement only and inherently not pressure balanced. Accordingly, bearings must be sturdy and pressures relatively low. Gear pumps can be made reversible and like vane pumps are available for use as motors.

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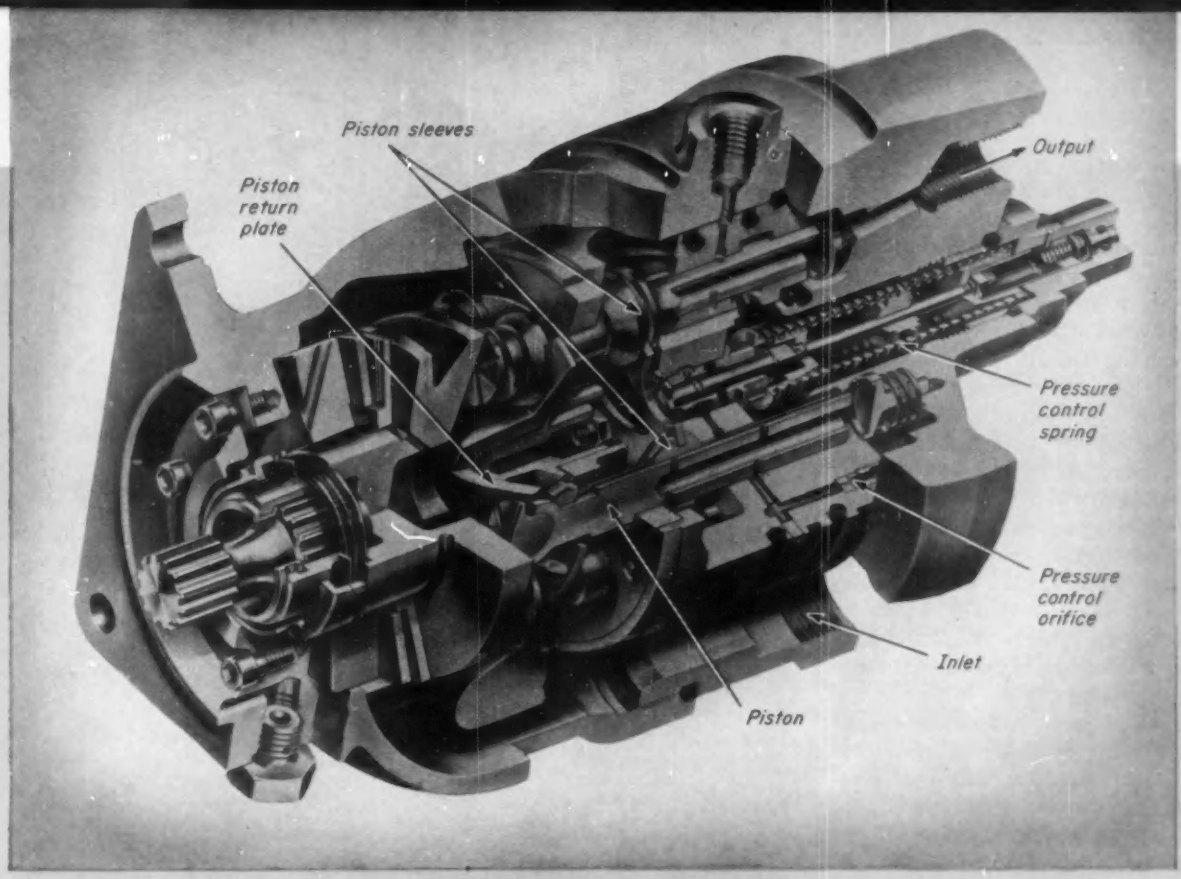
EASE OF CONTROL, small size, and adaptability to automatic operation inherent in hydraulic transmission of power has lead to its extensive use in machine tools, materials handling, and aircraft. Heart of the hydraulic power system is the positive displacement pump, and selection of the proper type—piston, gear, or vane,—depends on the fluid used, pressure, speed, temperature, life, weight, size and cost.

Piston Pumps

Earlier forms produced a pulsating flow which limited their application; other types gave the relatively smoother flow and greater simplicity needed in water systems, and



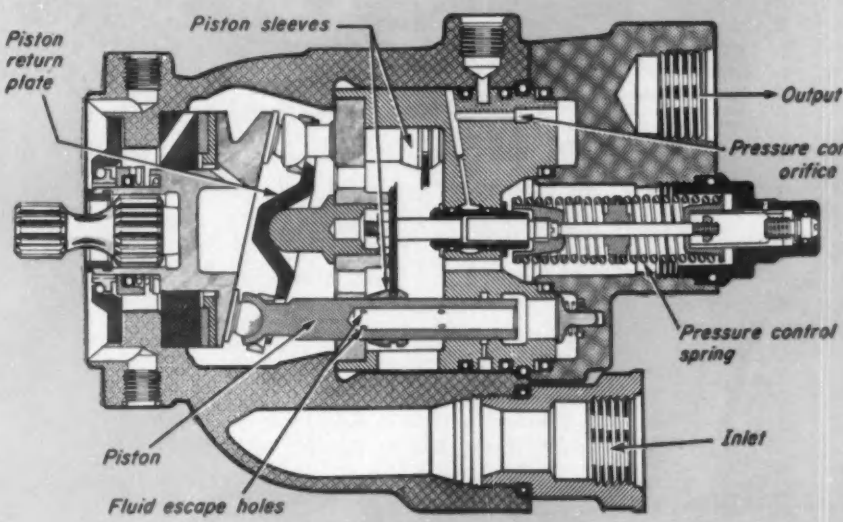


Fig. 2—In this variable-delivery piston pump, flow is controlled by the discharge pressure. As the pressure increases, the piston sleeves adjust the amount of fluid permitted to flow back to the inlet side.

handling of oil and fuel. However, requirements for higher operating pressures and speeds are leading to more use of piston pumps.

Power capacity of a pump is proportional to the product of fluid pressure, pump speed, and displacement. Since weight and size are primarily functions of displacement, an increase in pressure and speed reduces the pump size for the same power output.

Except for danger of cavitation, problems of higher pump speeds are mechanical: wear of bearings, shafts, and seals; friction heat; vibration and shock. Small piston pumps can operate at speeds over 6,000 rpm without exceeding critical fluid velocities. They are better suited to higher speed applications than gear and vane pumps.

Higher system pressure also reduces the size of other units in the system, requiring less fluid volume. Explosions are not dangerous since a small discharge of fluid is sufficient to reduce the pressure to zero. Piston pumps have been used at pressures over 8000 psi.

Ability to seal low viscosity fluids permits piston pump operation at temperatures above 400 F.

Leakage presents a serious problem in going to higher fluid pressures. Lower viscosity produces more leakage and loss of volumetric efficiency. Although reduced viscosity gives added resistance to cavitation by freer flow into the pump, the loss from reduced volumetric efficiency is greater than the gain by easier inlet flow. Better fluids are needed, especially for wide temperature ranges such

as encountered in aircraft hydraulic systems. Greater corrosion resistance, reduced toxicity, better lubricating properties, and reduced inflammability also are needed. (See editor's note at end of article for reference to a recent discussion of hydraulic fluids.)

Minimum leakage is achieved with highest pump speeds, minimum orifice area and increased circumferential length of orifice. Clearances between moving faces are limited to the minimum lubricant film thickness. Smaller clearances are possible in piston pumps and longer engagement between piston and cylinder provides the surface area to resist wear in piston pumps. Cylinders and pistons are easily produced and held to close tolerances and have a life on par with other pump types.

The piston pump has reassumed leadership because of higher delivery pressures, better efficiencies over wide pressure or temperature ranges, and more effective fluid intake. Pulsations of discharge flow in high speed multiple piston pumps have been reduced to negligible amounts, and increased fluid compression also damps pulsation peaks. Performances of different pumps, representing actual test data are shown in Fig. 1. Advantages of piston pumps over others are most evident at higher pressures and speeds.

Piston pumps are easily built for variable delivery. In one method the piston stroke is varied by changing the throw of a swashplate, cam, or eccentric. In another, a sleeve rides over piston port holes with sleeve control allowing a varying amount of fluid escape to the inlet side.

Variable delivery control may be obtained manually, mechanically, electrically or by pressure regulation within a "pressure cut-off range." With one form of pressure regulation at minimum pressure the pump delivers maximum flow and flow decreases to zero at the maximum pressure limit. Selection of pressure ranges is a function of mechanical spring design. Fig. 2 shows a variable delivery pump with postive piston return and automatic pressure control.

Variable delivery pumps will deliver the exact power and flow required resulting in systems with relatively high efficiency. These pumps are light, small, reliable, easily designed, and have little need of control valves. Systems using constant delivery pumps are less efficient when less than full delivery is used. A typical constant delivery pump is shown in Fig. 3.

Progress in high pressure piston pumps is being paralleled by that of control valves, fittings, couplings and hose. Elastic seals capable of withstanding heat without deterioration or loss of shape and elasticity are still needed.

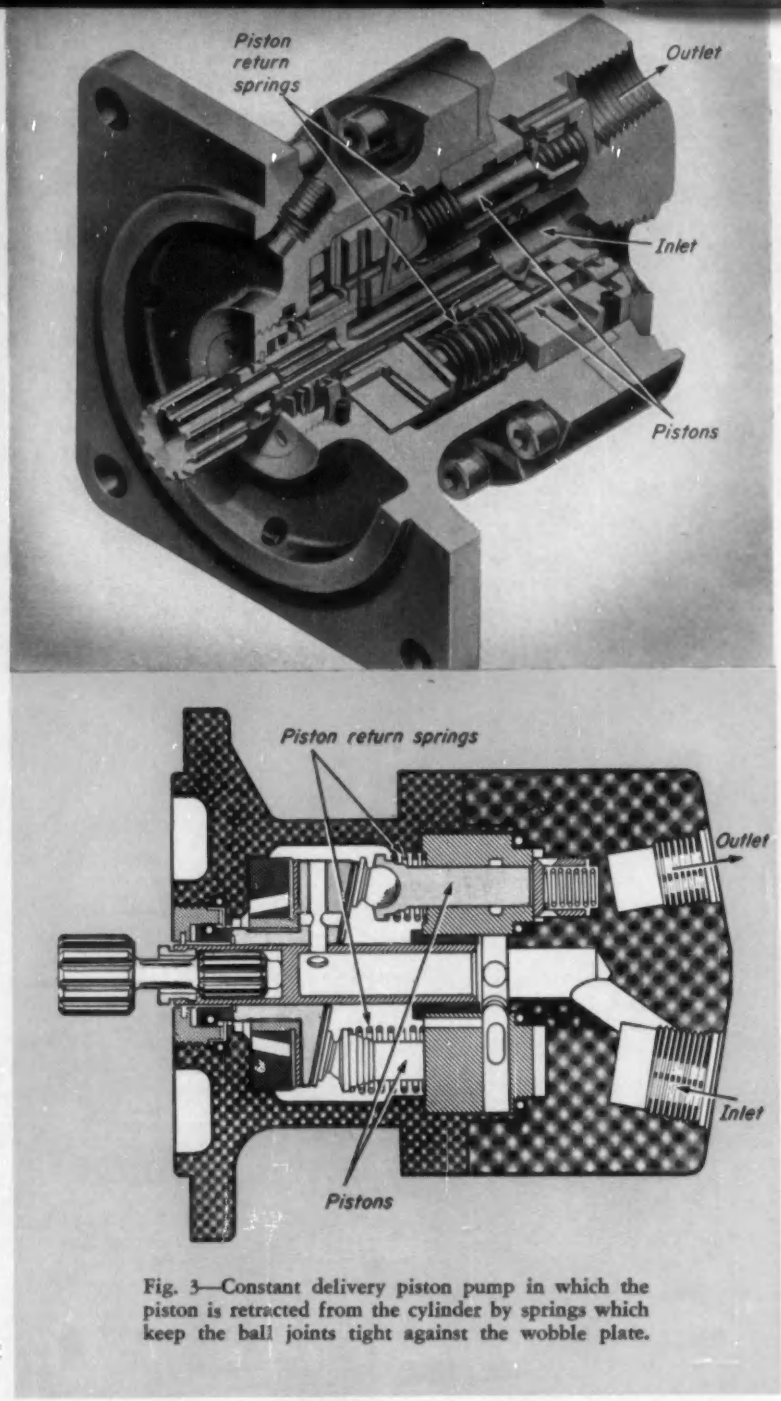


Fig. 3—Constant delivery piston pump in which the piston is retracted from the cylinder by springs which keep the ball joints tight against the wobble plate.

Vane Pumps

Flow rates of fixed displacement pumps range from 2 to 120 gpm at pressure ratings to 2,000 psi in standard assemblies. An advantage of vane pumps is their small size as illustrated in Fig. 4. Speeds range from 400 to over 2,000 rpm. Fluids ordinarily used are mineral-base oils with viscosities from 70 to 300 SSU at operating temperatures. Varied temperatures and speeds as well as exceptional conditions such as a fire hazard, occasion use of other fluids.

The space between the rotor and cam ring of the pump in Fig. 5 is divided into a number of compartments by vanes free to slide in rotor slots. As each compartment increases in size, fluid flows into the compartment. As it decreases in size fluid is discharged under pressure.

There are two diametrically opposed intake ports and,

similarly, two discharge ports. Hydraulic forces applied to the rotor are balanced so that rotor bearing loads are low. In fixed-displacement vane pumps the heavily loaded vanes need not move in their rotor slots since, during this portion of the rotary cycle, the contour of the cam ring can provide a true arc about the center of rotation. The cam track has four such arcs, and the movement of fluid into and out of the pump occurs at sections between these four arcs. The main conversion of mechanical to hydraulic power in the pump occurs at the true radius sections of the cam ring.

Displacement of oil from the rotor slots may be used to contribute to the pump output. In general, this represents an increase of 10 to 15 per cent of the displacement of the pump. Porting provisions are then required for inlet and outlet flows from the rotor slots.

When slot displacement is used, slots are pressurized during only part of the rotary cycle, if not, they are always pressurized in order to assure the vanes remaining in contact with the cam ring. In either case there are portions of the cycle in which the vanes are unbalanced, which limits the maximum pressure at which the pump may be operated. Radial thrust of the vanes may be substantially balanced by creation of a connected opposing area shown in more detail in Fig. 6. Having minimized the unbalanced thrust, thicker and stronger vanes may be used permitting higher pressures.

A detailed analysis of the transformation from mechanical to hydraulic power is beyond the scope of this article.

The cam ring of variable displacement pumps is a perfect circle. There is only one intake port and one discharge port providing only half the delivery volume of the equivalent fixed displacement pump and considerable unbalance of load on the bearings. Variable displacement is acquired by movement of the cam ring with respect to the rotor.

Standard sizes of variable displacement pumps supply up to 70 gpm at full displacement, and maximum power about 45 horsepower. The shaft bearing capacities, vane thickness, and mechanical load against the cam ring limit the pressure ratings of these pumps to 1,000 psi.

Flow rate may be controlled manually, electrically, mechanically, pneumatically or by system pressure. High pressures are associated with low flow rates and low pressures with high flow rates. Combination of fixed displacement pumps with properly associated control valves can

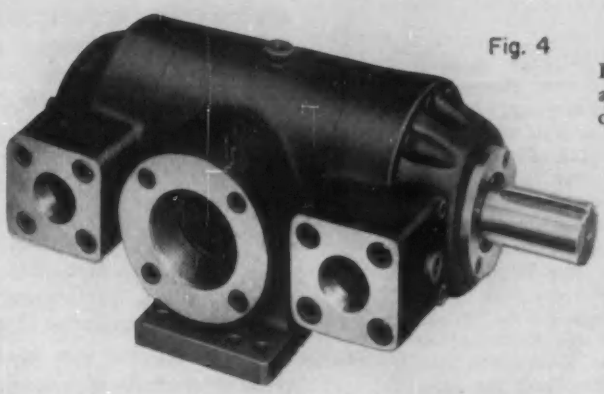


Fig. 4—This dual-vane pump delivering 120 gpm at 2,000 psi has a nominal capacity of 135 hp output and is only 17 in. long.

Fig. 5—Section through fixed displacement vane pump showing hydraulic balance of pressure and discharge areas. Bearing loads are thereby reduced to purely mechanical loads.

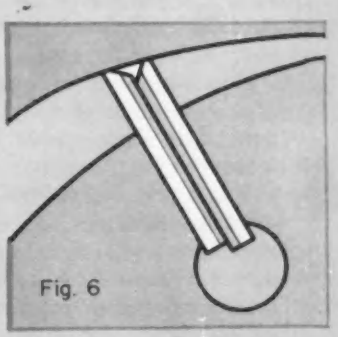
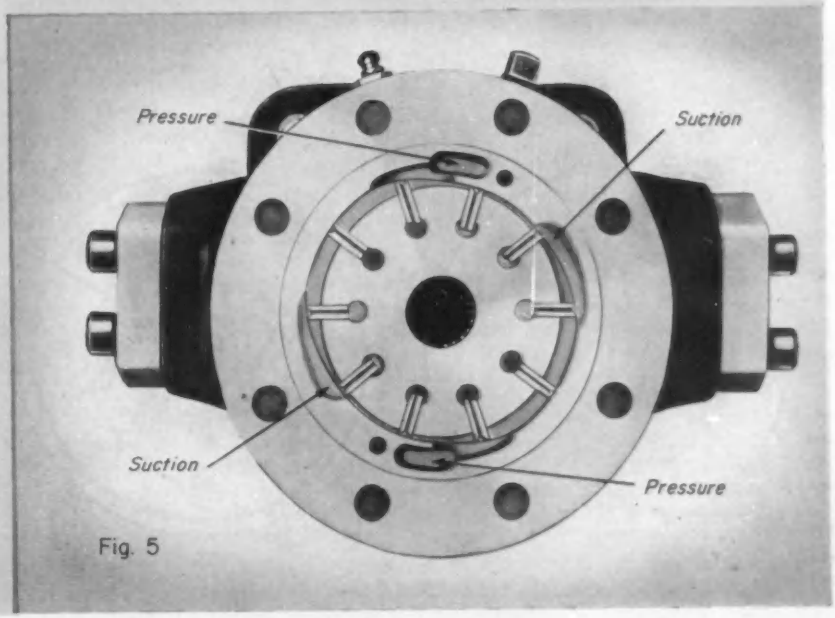


Fig. 6—Each vane is composed of two parts sliding freely relative to each other and providing a connecting passage between the pocket underneath the vane and the space between vanes.



also provide specific combinations of flow rates and pressures. If desired, the system can be designed to give constant horsepower over the entire operating range.

Volumetric efficiency of variable displacement pumps is poorer than that of fixed displacement pumps. It is affected by clearance slippage of the sides, or faces, of a cam ring, since this ring must be free to slide to the various positions of eccentricity. Size of the rotating elements of these pumps also influences the slippage rates, and the fixed displacement pump is invariably smaller than the variable displacement pump delivering the same flow rate.

Smoothness of operation of any pump is based on the uniformity of displacement rate, the consistency of the rate of clearance slippage through the rotary cycle, and the relative size of the compartments being pressurized. On this basis the relatively smooth, quiet operation and long life of vane pumps is understood.

It is notable that the displacement of a particular pumping assembly may be revised to any of several other displacements by interchange of cam ring, and a variety of combinations of two pumping sections in a standard assembly are available from some manufacturers.

Gear Pumps

The pumping action of a gear pump is shown in Fig. 7. When the gears rotate, oil fills the tooth spaces and is carried around to the discharge side of the pump where the oil is expelled as the teeth come into mesh.

There are also internal gear pumps having a crescent separating the rotor from the roller, or with a special tooth form where the internal gear or roller has one tooth less than the external or rotor gear.

Some pumps use pressure loaded wear plates on either side of the gear. This results in increased volumetric efficiencies; however, it is accomplished at the expense of some loss of mechanical efficiency. The usual external gear pump is of the fixed clearance type with the gears running in a housing and contained by two side or wear plates.

Gear pumps are of the fixed displacement type. There are no successful variable displacement gear type pumps of which the writer is aware. It may be possible to make such a pump, but basically, the gear pump is not suited to the variable displacement design.

Gear pumps are manufactured in a very wide range of capacities from one gallon per hour up to 300 gpm, and of horsepower from a fraction of a horsepower to 200 hp. The majority of gear pumps are made for the moderate pressure ranges, most of them for pressures up to 1,000 psi. There are a number of gear pumps available for pressures of 1,500 and 2,000 psi and a limited number of pumps available in the 3,000 psi pressure class.

Gear pumps are inherently hydraulically unbalanced, therefore consideration has to be given to unusually high bearing loads. Materials are available to accommodate these bearing loads and gear pumps can successfully be designed for relatively high pressures.

Gear pumps are well suited to a high range of speed requirements. They operate very satisfactorily at speeds as low as 200 rpm and up to 3,600 to 4,000 rpm. One automotive installation is operating at speeds up to 9,000 rpm. At high speed the difficulty is to completely fill the tooth spaces. As the gears rotate there is a tendency for the gear teeth to kick out the oil as it is attempting to enter the space, since the gear teeth are traveling at a much greater speed than is the oil as it enters the inlet side of the

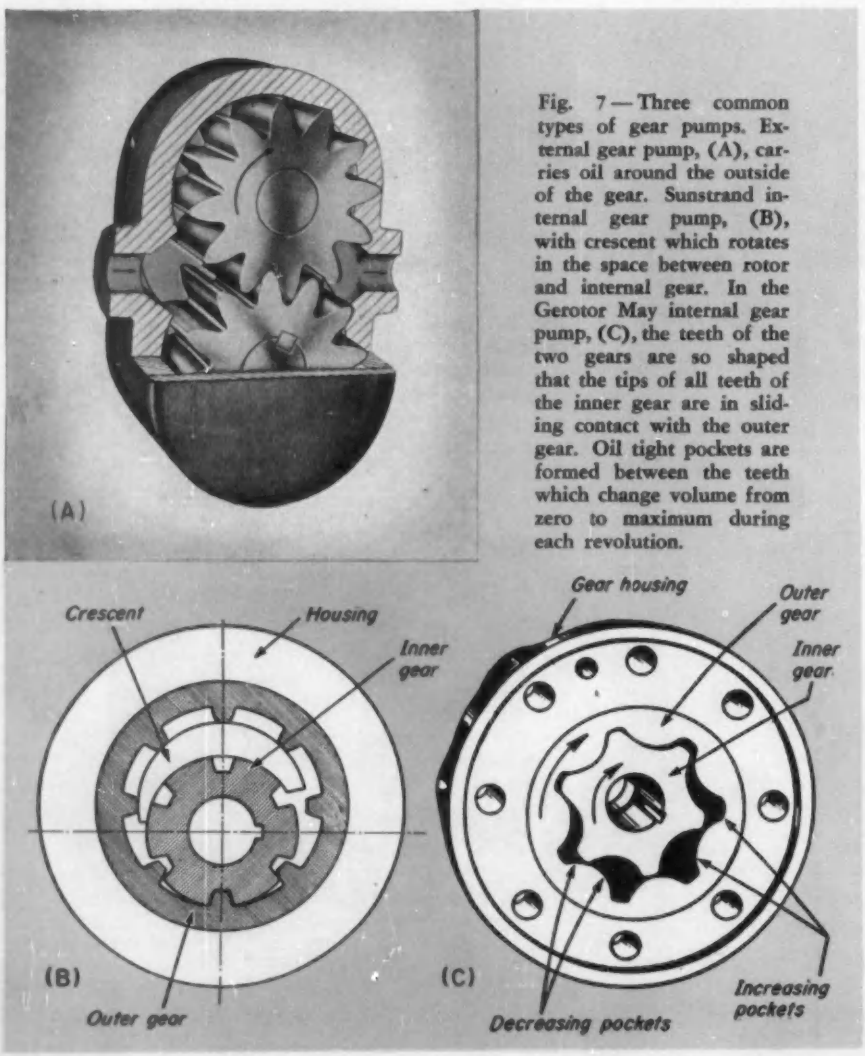


Fig. 7 — Three common types of gear pumps. External gear pump, (A), carries oil around the outside of the gear. Sunstrand internal gear pump, (B), with crescent which rotates in the space between rotor and internal gear. In the Gerotor May internal gear pump, (C), the teeth of the two gears are so shaped that the tips of all teeth of the inner gear are in sliding contact with the outer gear. Oil tight pockets are formed between the teeth which change volume from zero to maximum during each revolution.

Fig. 8—Radial holes drilled in the driven gear of Barnes pump permit trapped oil to escape through a passage in the stationary shaft to the discharge side. This reduces bearing loads and increases efficiency.

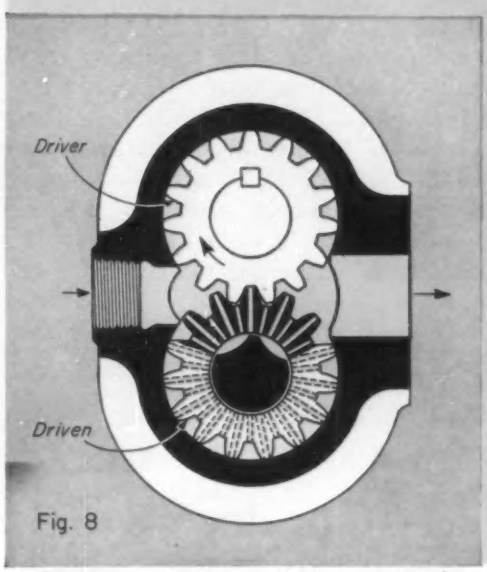


Fig. 8

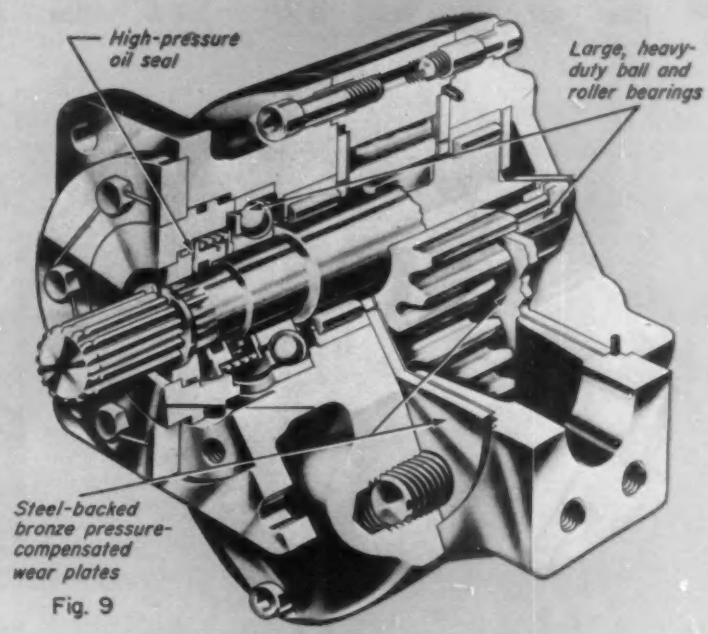

High-pressure oil seal
Large, heavy-duty ball and roller bearings
Steel-backed bronze pressure-compensated wear plates
Fig. 9

Fig. 9—The high pressure seal in this gear pump permits reversibility of operation.

pump. To achieve a better match of gear tooth and oil speeds, one type of pump has a venturi on the inlet side of the pump. It is also possible to use an orifice at this point to accelerate the oil, or to supercharge the pump with another gear pump or a centrifugal pump.

In observing the action of the gears in Fig. 7 it can be seen that as the gears mesh on the discharge side there is a possibility of trapping oil in the bottom of the tooth space. Some pumps have pockets in the wear plates to relieve this trapped oil. An unusual solution, shown in Fig. 8, uses a special tooth form in which the tooth space is completely filled by the teeth as they mesh. Oil trapped in the bottom of the tooth space flows through small holes drilled through the teeth and is ported back to the discharge side by a milled pocket in the driven gear shaft. Relieving the trapped oil reduces the thrust that might otherwise tend to separate the gears.

Gear pumps are simple in design and with the addition of a high pressure seal as shown in Fig. 9, will operate in either direction. The reversibility feature provides a very desirable versatility to serviceman, manufacturer, and installer. Some gear pumps can be used as hydraulic motors, however, the sliding friction on the end plates reduces the efficiency to the point that good starting torques are sacrificed.

Perhaps the biggest single factor in favor of using a gear pump is its low cost. This is due to its simplicity of design and ease of manufacture. The gear pump is well suited to mobile applications since there are no parts to break easily at low temperatures when fluids become viscous.

Dirt should not be permitted to enter any hydraulic system; however, a gear pump can handle such foreign particles better than other types of pumps. The gears tend to sling the foreign solid particles to the outer rim of the gears and expel them into the system. The wear to the gears will gradually reduce its efficiency and the ability to deliver the required amount of oil under pressure, but in other types of pumps, seizure or breakage results. Generally speaking, this sudden failure is not as desirable as a gradual loss of efficiency.

Perhaps the one single disadvantage of the gear pump is that it is noisier than other types, but low cost, good efficiency, wide speed range, moderate pressures, and ruggedness are its advantages.

EDITOR'S NOTE—A discussion of "Synthetic Hydraulic Fluids by S. S. Harris, appeared in *Product Engineering*, December 1954, starting on page 163. Their characteristics, advantages, and disadvantages are compared to petroleum oils. See also "Which Characteristics for Hydraulic Fluid," by B. B. Flick, August 1953, page 149, for a discussion of desirable characteristics of hydraulic fluids.

"Hydraulics for High Horsepower Application," by M. A. Hayden, February 1955, page 129, discussed the factors influencing the design of hydraulic circuits and included sample calculations for determining pump and motor sizes.

Problems of sealing, always present in pump applications were discussed in "How to Prevent Oil Seal Failure," by R. O. Isenbarger in January 1953, page 154. Sketches of radial and axial seals are included plus a check list for setting up seal specifications.

"Hermetically Sealed Pump-Motor Units Will Handle Any Fluid," by E. F. Bull in June 1953, page 216, described an unusual bearing and integral motor pump design.

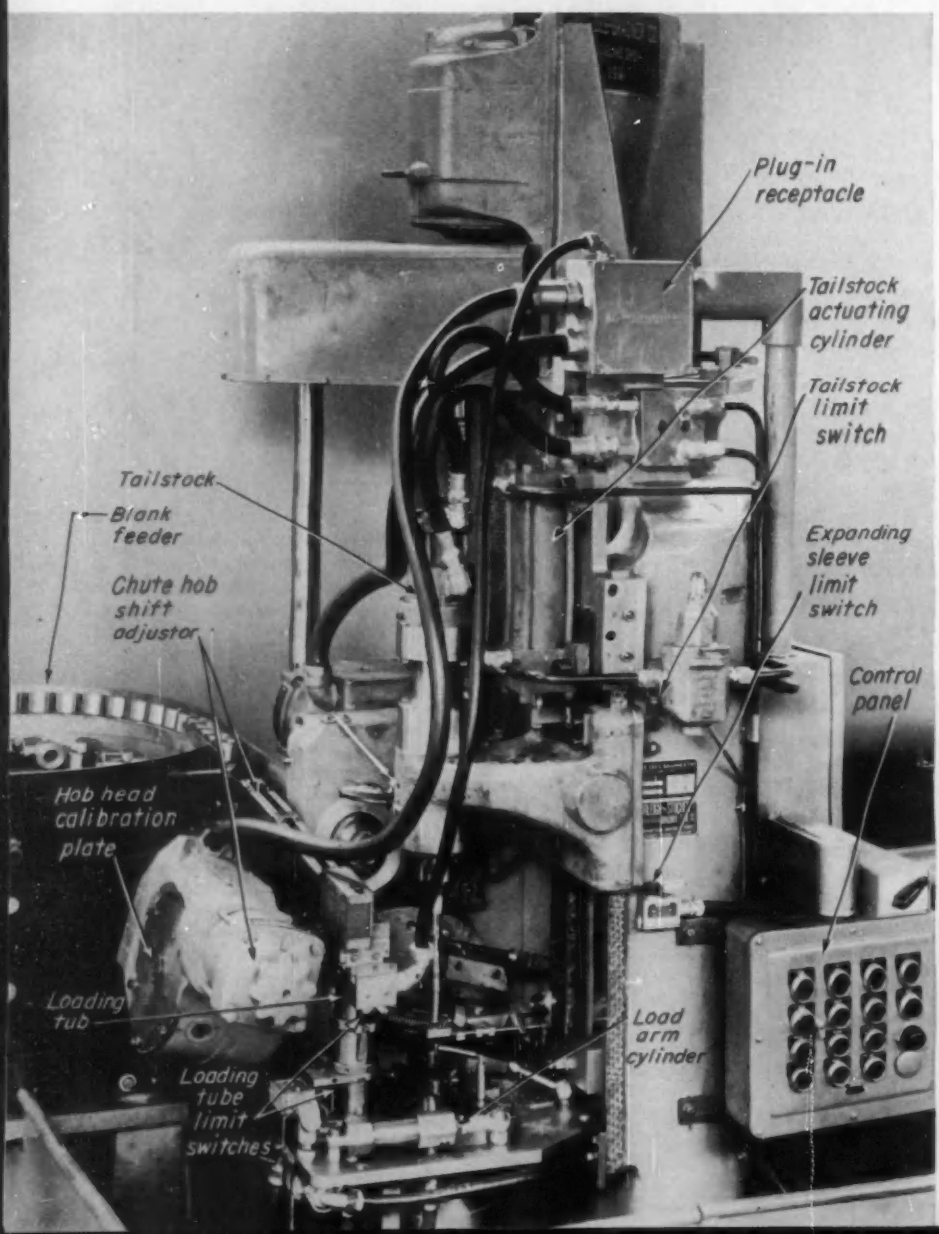
A two-part article on "Spur Gear Rotary Pump Design," by T. F. Fitzgibbon appeared in January 1951, page 101, and March 1951, page 129. The first part discusses the problems in gear and bearing design; the second covers leakage, housing construction details, gaskets and packing requirements.

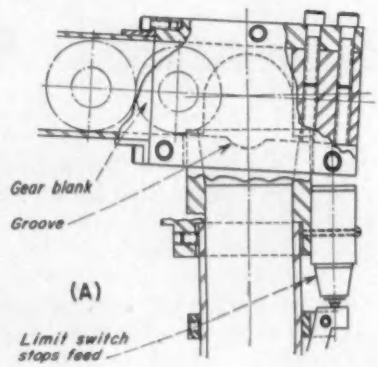
DESIGN FEATURES

Electronically Controlled Hobbing Machine

A hobbing machine that approaches fully automatic operation has been developed by the Lees-Bradner Co., Cleveland, Ohio, in conjunction with Airborne Instruments Laboratories, Inc., Mineola, N. Y. A built-in control system for gear hobbing maintains uniform pitch diameter and provides for maximum hob life. Blanks are hopper fed and finished work is automatically sorted.

Development of the automatic control was undertaken primarily to reduce scrap; in the

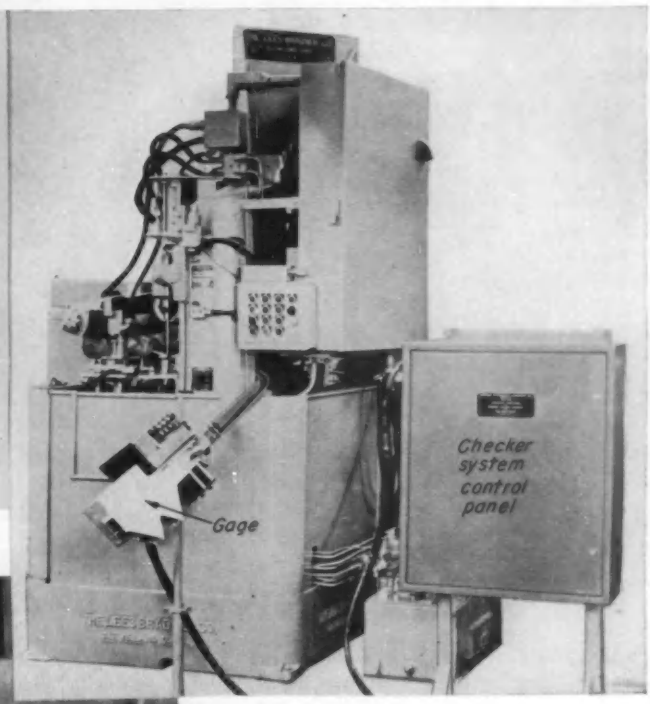


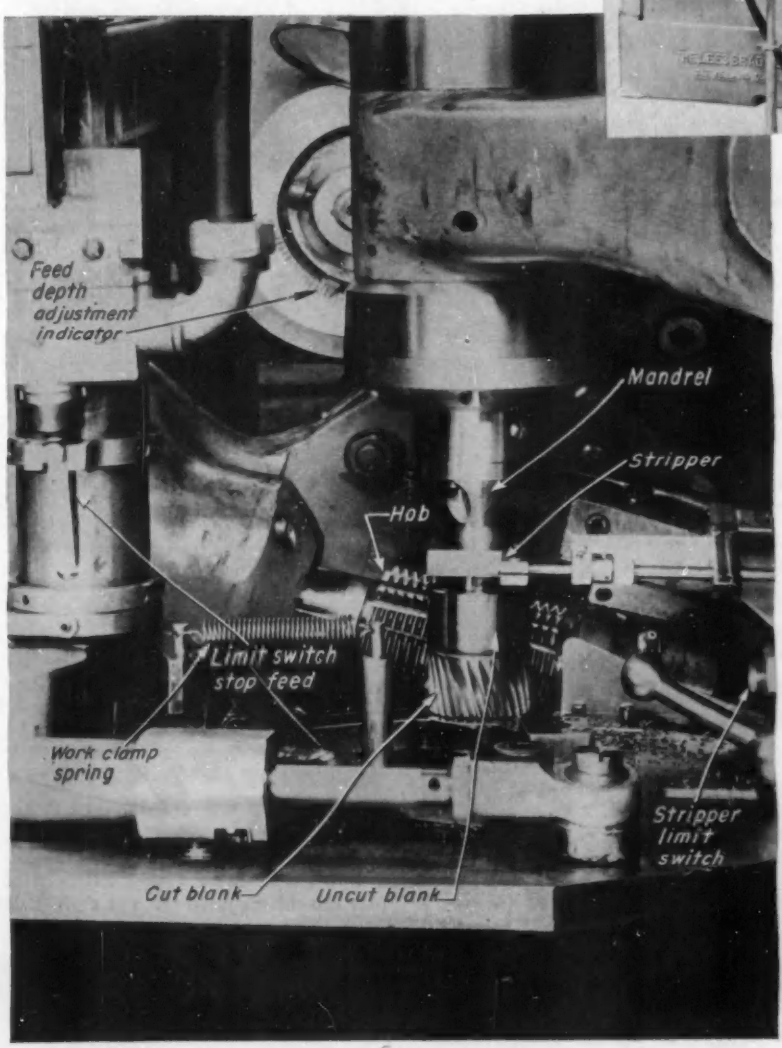


BLANKS ARE FED from hopper, down chute, into loading magazine. Transfer arm brings blanks into position, and tailstock descends to lock into work spindle bushing. Hob cycle is rectilinear —return, in-feed, feed and out. As arm carries new blanks into position, finished work is pushed off into chute to gage unit. Hopper operation is controlled by two limit switches: lower switch starts hopper when blanks drop to fixed minimum amount and upper switch stops hopper after magazine receives fixed maximum supply. Hob cycles only on sufficient magazine supply; hopper operates only during return cycle of hob to eliminate effect of vibrations on accuracy of cut. (A) This 90-deg turnover unit drops blanks from chute into magazine. Formerly, blanks were fed down chute with face flat, and pushed into magazine by solenoid control. In dropping, leading edge of blank caused cocking in magazine. Recessed groove in chute opening prevents cocking.

method adopted a continuous check of pitch diameter is fed back into machine to adjust cutting depth when necessary. Additional check for root fillet buildup was later added; on predetermined amount of buildup, gage signals machine to shift the hob.

Guiding requirements were that the control system work through basic machine mechanisms and synchronize with work cycle. It was nisms and synchronize with work cycle. It was also necessary that the tolerance range be adjustable, and that the control system be reliable.





HOBBING MACHINE to which the checker control panel and gage have been added. Originally, hobbing unit was manually loaded and unloaded each work cycle but production demands required automatic operation. Gage checks pitch diameter and root fillet and feeds signals to machine to adjust depth of cut and shift hob when required to keep gears within tolerance. Inspected gears are sorted into three groups—acceptable, salvageable and non-salvageable.

REDESIGN of work setup was necessary to convert from manual to automatic load and unload. Hydraulically actuated transfer arm with spring-loaded clamp was introduced, and swivel table installed. Mandrel location was changed from work spindle to tailstock, to allow swing of transfer arm. A stripper was devised to guard against locking of finished work to mandrel on upward travel of tailstock. At first, when bolted to table, stripper was repeatedly torn loose; now microswitch is tripped by stripper, stopping machine. Two or more gear blanks are loaded on the mandrel to minimize approach time per blank.

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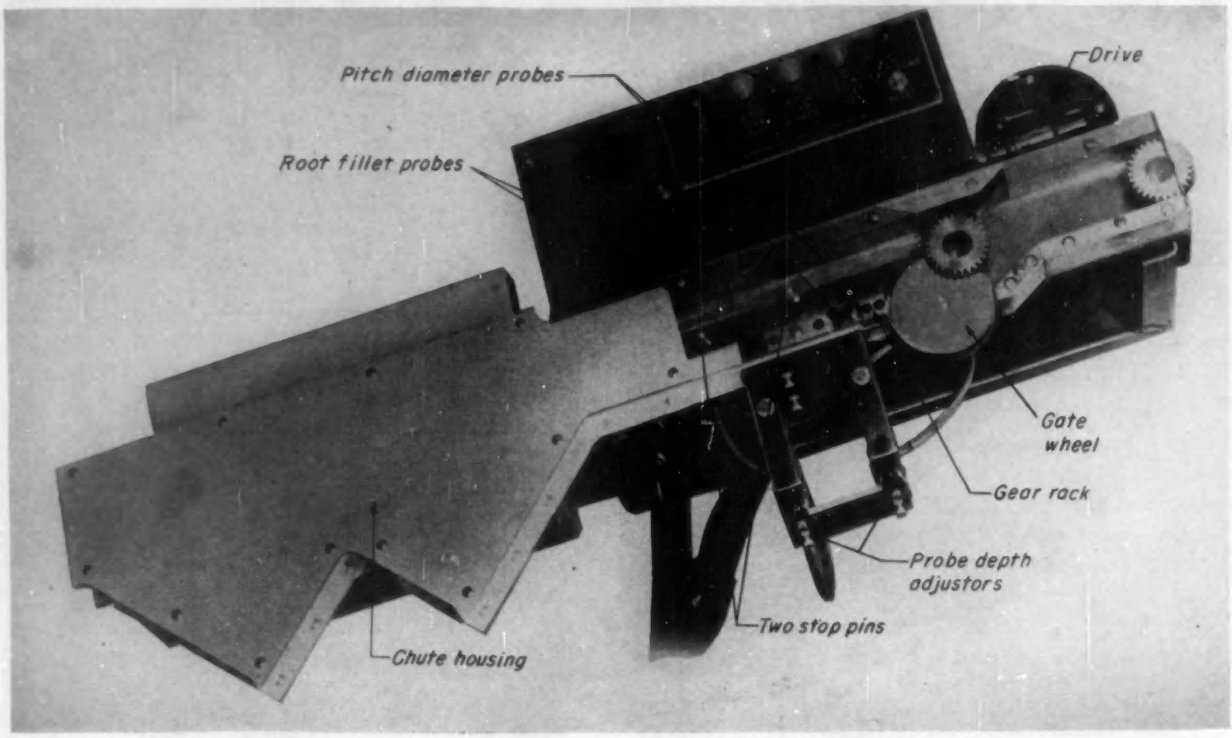
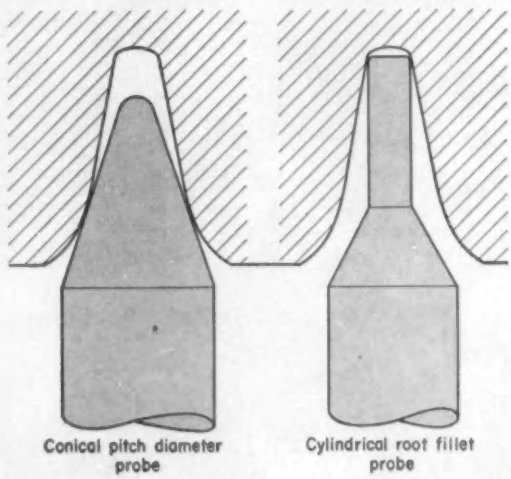
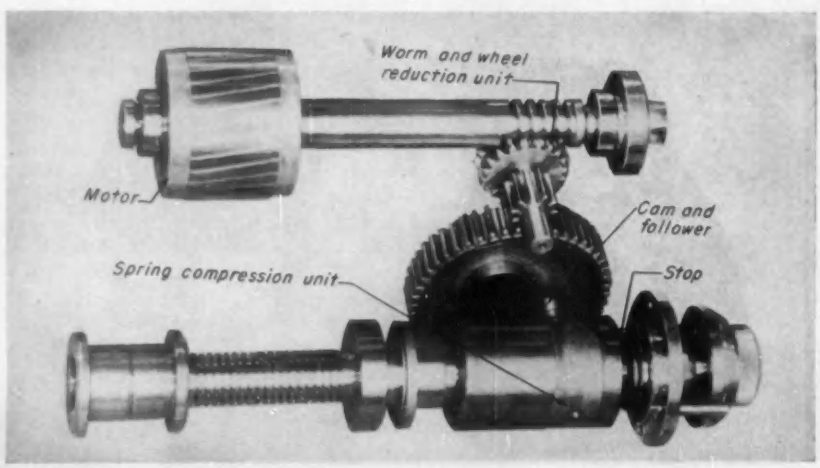
Hobbing Machine (continued)



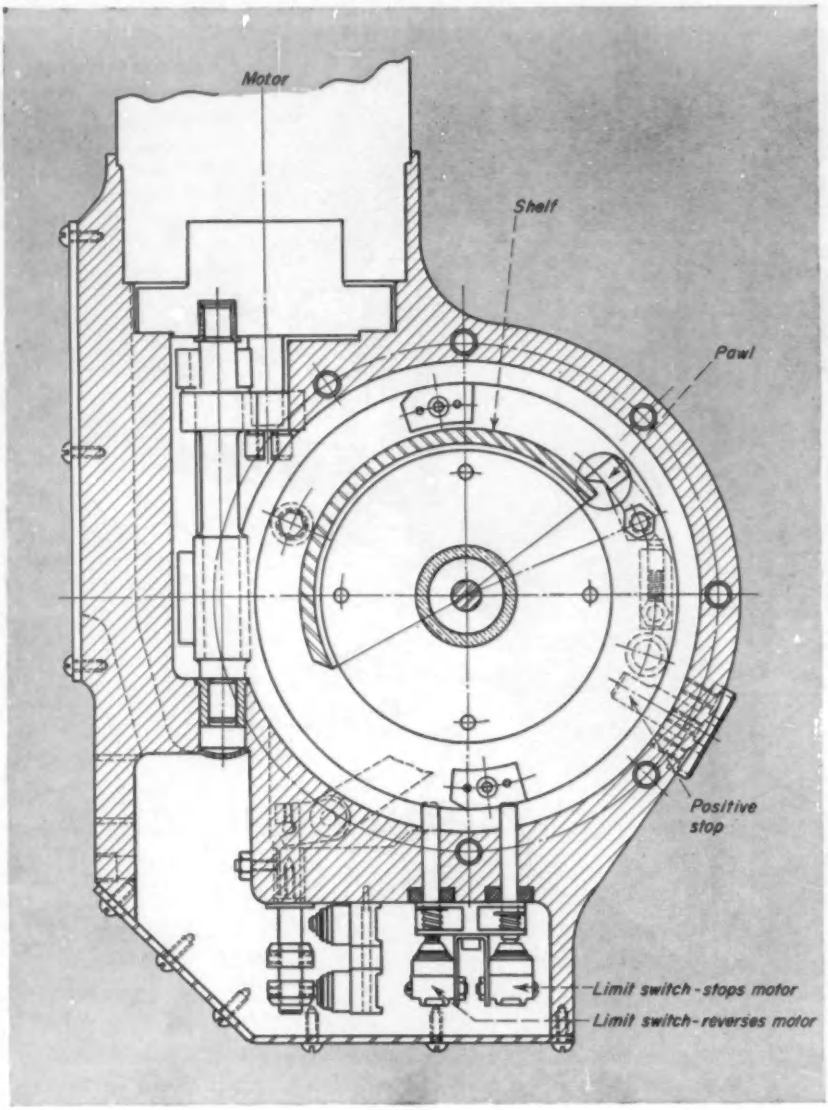
(ABOVE) Gears are gravity fed into checker unit, entering recess in gate wheel. Turning counterclockwise, wheel meshes gear with rack. For pitch diameter check, gear is guided to first stop pin. Upper pitch diameter probe moves down, making contact with tooth face, and stop pin retracts. Lower pitch diameter probe, forced downward by gear, actuates transducer; probe displacement is a function of pitch diameter. Gear is then advanced to second stop pin and root fillet is checked by a similar probe action. Gears are sorted into one of three chutes by solenoid controlled vanes.

(RIGHT) In developing the gaging system both ball-type and master-gear gaging were considered. Ball-type method was chosen because of lower initial cost, less re-tooling and smaller chance of chip interference. To check pitch diameter, left, probe makes contact on tooth face as shown. Advantage of point contact is that any eccentricity between gear bore and pitch circle has no influence on accuracy of pitch diameter. Fillet growth was found to be rapid once started and thus a sensitive indicator of hob wear. Probe measures buildup at most critical section.





(LEFT) In-and-out mechanism regulates depth of hob feed, and hence, the pitch diameter of work. Cam follower drives feed screw connected to hob slide (not shown) to move slide in and out. Spring in compression unit cushions any tendency of slide to exceed depth set by mechanical stop. Automatic depth adjustment is made by a pawl and ratchet (not shown) mounted on stop shaft and solenoid-actuated by checker unit. Formerly, mechanical stop was adjusted by wrench. At retract of hob, the stop has no load, minimizing torque that tends to act against adjustment.



(LEFT) Hob shift was readily adaptable to electrical control. On receipt of signal from checker unit calling for hob shift, relay starts motor to drive worm wheel. Pawl mounted on worm wheel rides shelf, dropping off to engage ratchet wheel. Ratchet turns screw that drives hob arbor in axial direction. As wheel hits mechanical stop, limit switch is closed, reversing the motor; pawl is returned to original position. Before developing the checker control, hob shift was governed by electrical counters, set by operator; a pre-production run determined numbers of gears that could be hobbed between hob shifts. Now, increase in root fillet build-up determines when hob is shifted.

(BELOW) Stepping relays signal in-and-out mechanism to adjust feed depth only after successive passage of three gears outside required pitch tolerance. Machine is stopped if ten gears pass exceeding tolerance limits. Three was adopted as criterion on basis of probability of accidental chip interference and normal variation of machine. In-and-out increment adjustment is fixed at 0.0005 in., an amount that keeps machine within production tolerance yet prevents hunting caused by variations. Hob is shifted after passage of two gears having fillet beyond established limit; machine is stopped, should ten gears pass having excessive fillet buildup.

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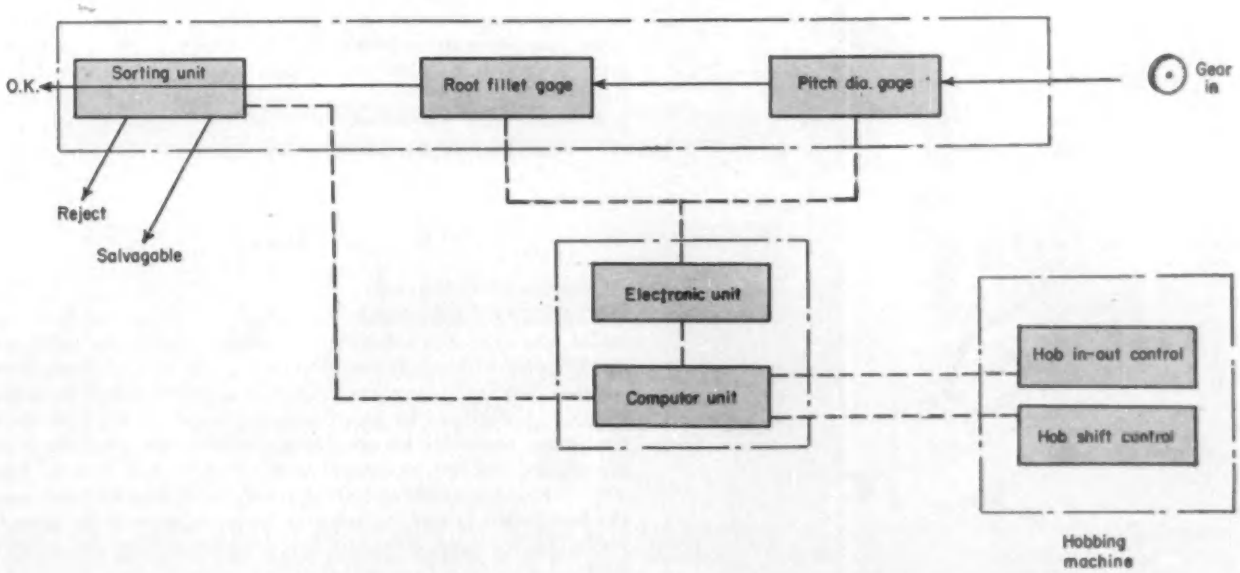
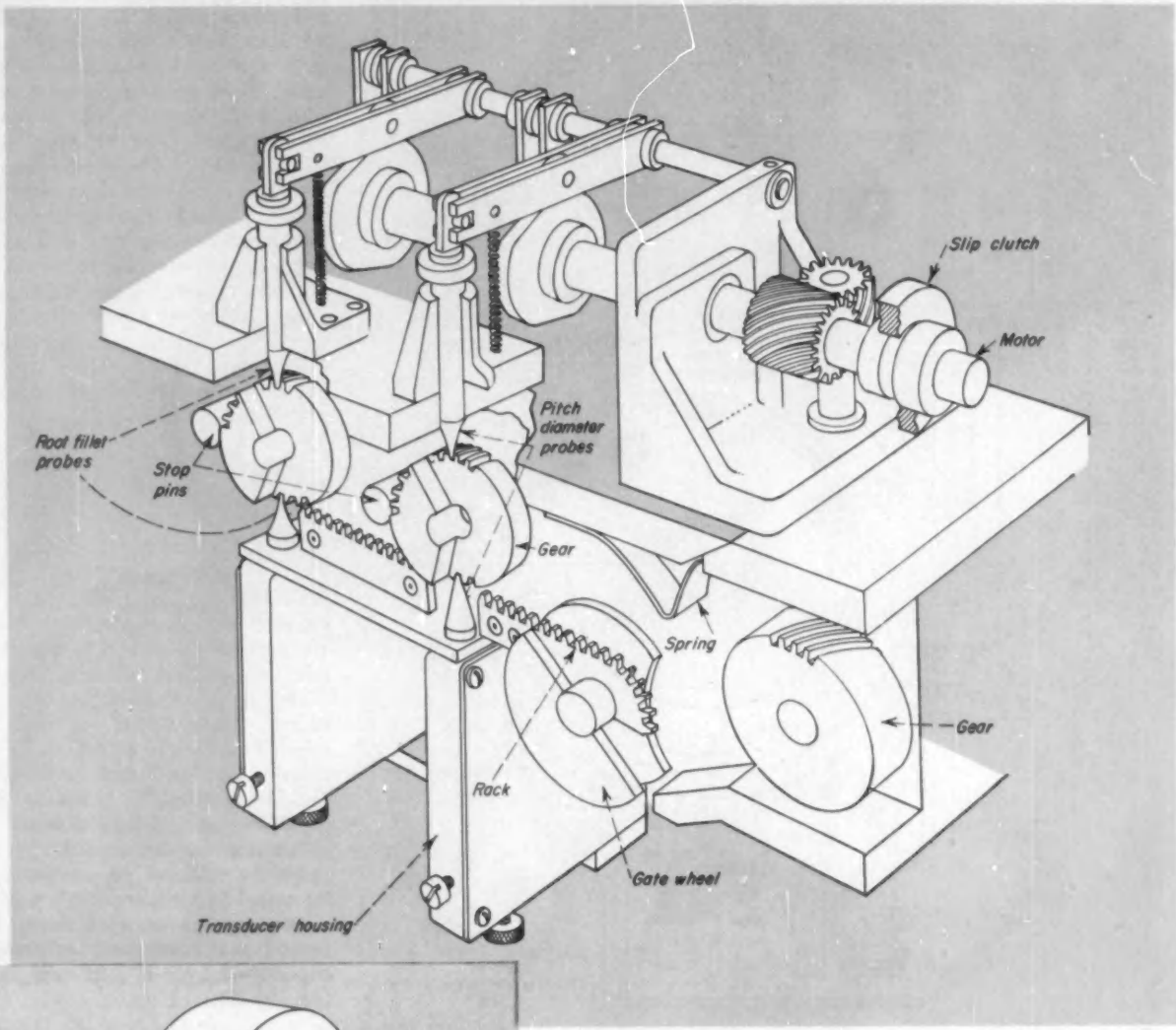
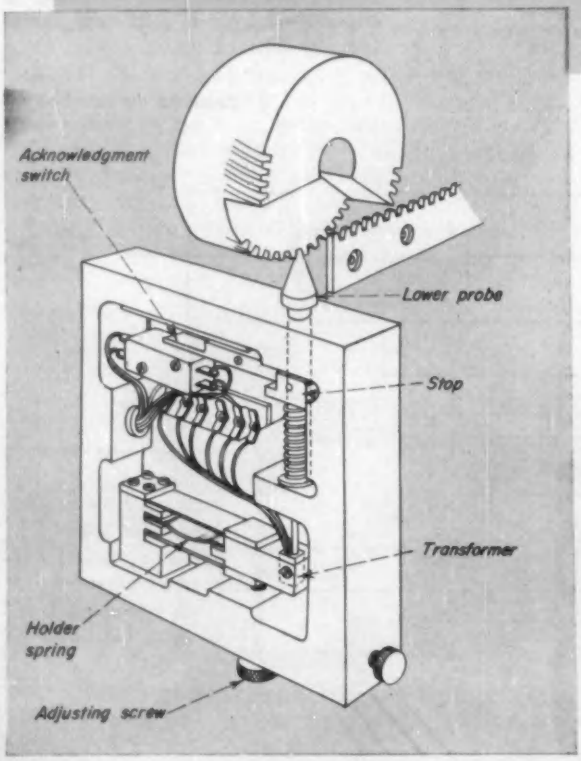


Hobbing Machine (continued)

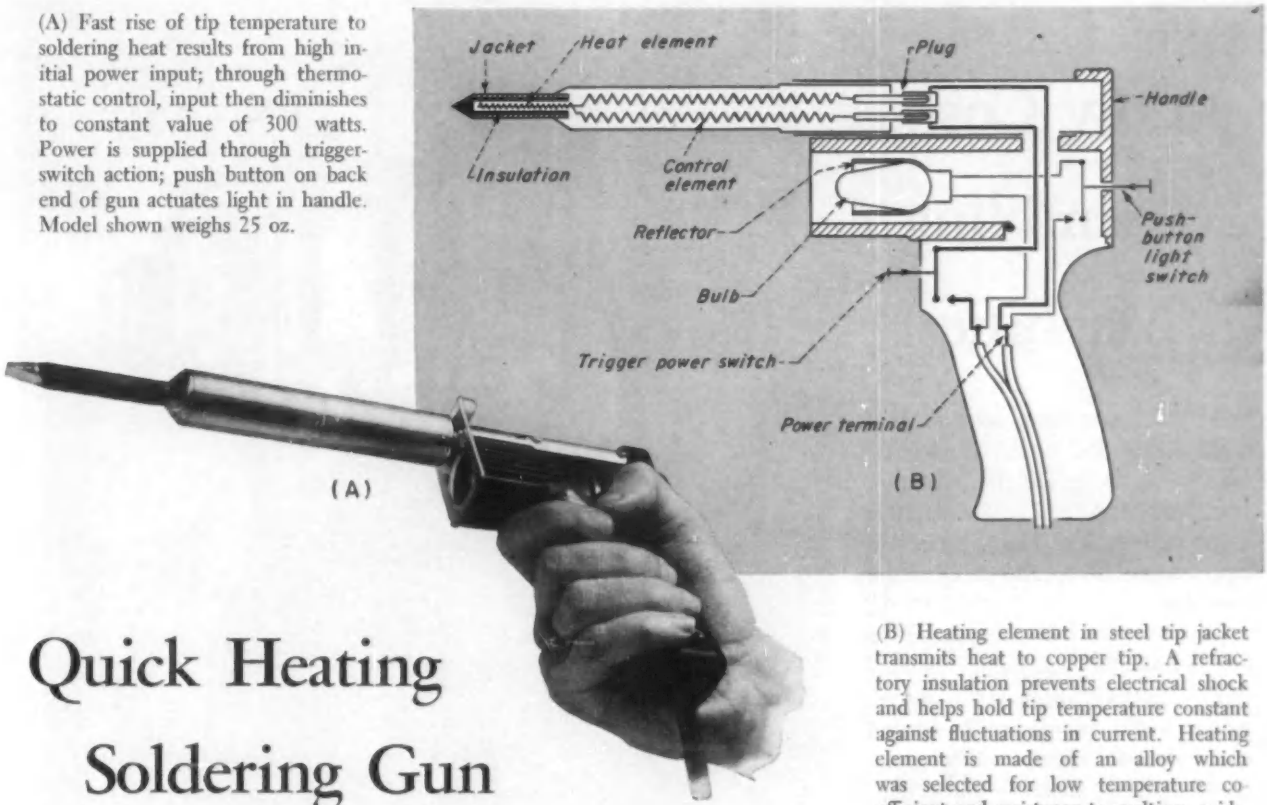




IN ORIGINAL DESIGN of checker unit, gear rack extended only slightly inside outer left edge of wheel; some gears rode tip of rack. A curved rack section was added so gear engages on first entering recess. Spring was added to insure positive mesh. Unit is driven independently of hobbing machine, and at faster rate to protect against jamming. Slip clutch prevents damage should jamming occur. Gate wheel is driven through two sets of helical gears; springs move stop pins out and probe pine down; cams retract both.

IN TRANSDUCER HOUSING, left, lower probe moves spring-loaded core shaft into differential transformer. Secondary coils, connected series bucking, deliver more voltage as core is driven from centered position in transformer. Acknowledgment switch is opened as probe is positioned by gear, connecting signal circuit. Differential transformer transducer was selected instead of a switch transducer for adjustability and less mechanical wear. Switch could indicate error only—not the magnitude of error. Further, the differential transformer can be adjusted to vary the tolerance limits. Gage sorts the gears to production tolerance limits, controls hobbing machine to narrower limits.

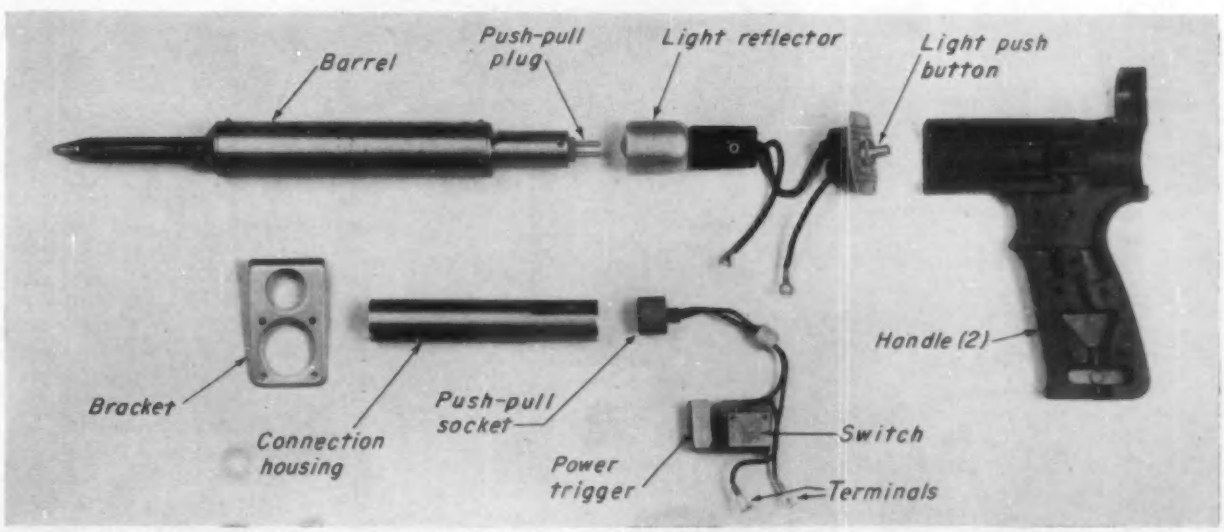
(A) Fast rise of tip temperature to soldering heat results from high initial power input; through thermostatic control, input then diminishes to constant value of 300 watts. Power is supplied through trigger-switch action; push button on back end of gun actuates light in handle. Model shown weighs 25 oz.



Quick Heating Soldering Gun

A quick-heat electric soldering gun with thermostat-controlled power output has been produced by the Wall Manufacturing Company, Grove City, Pa. The gun is lightweight, can operate on either a-c or d-c, and incorporates a built-in spotlight. Basic design requirements were high heat transfer capacity and maintenance of constant tip temperature whether standing by or repeatedly used.

(B) Heating element in steel tip jacket transmits heat to copper tip. A refractory insulation prevents electrical shock and helps hold tip temperature constant against fluctuations in current. Heating element is made of an alloy which was selected for low temperature coefficient and resistance to melting, oxidation and corrosion. Control element, a different alloy, has high temperature coefficient to resistance necessary for particular application. Following initial current surge, resistance increases, to reduce input current until equilibrium condition is attained. Any subsequent change in current is compensated for by change in resistance of control element, keeping tip temperature constant.



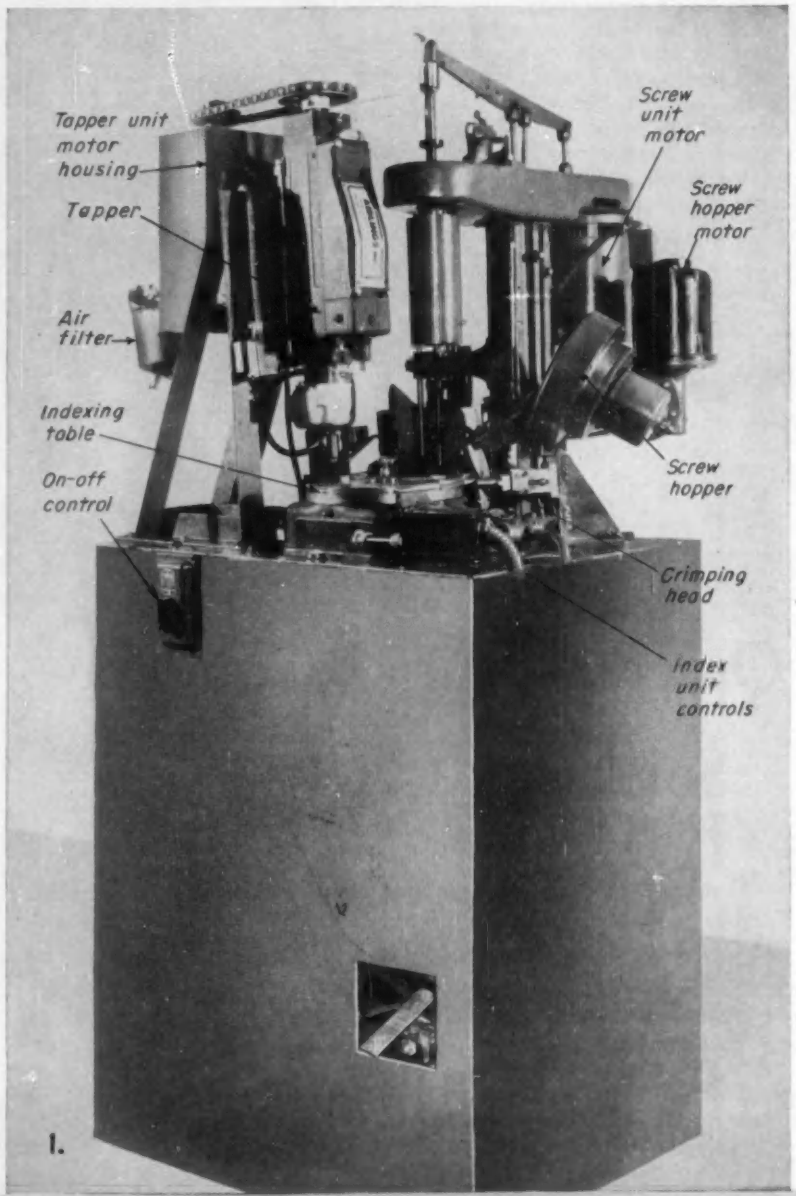
PLUG-IN CONNECTION is used so same handle may be adapted to variety of tips. Large barrel is required to keep surface temperature within safety limits. Plastic handle is disassembled by removal of screws, for servicing of light, switches and connections. Note that handle is recessed inside to hold components in place eliminating need for any fastenings.

Low Cost Assembling Machine

A basic assembling machine that can be modified to the application has been conceived by Aidlings, Inc., New York, N. Y. The machine incorporates low cost standard equipment with specially engineered components.

Machine has been adapted to semi-automatic ear-piece production. Compact unit was required, which could be manually loaded and indexed. Three tooling operations—tapping, screwing and crimping—had to be performed in the assembly of the three ear-piece parts.

Standard screw driver unit, tapper and crimper were used, while a new screw driver bit was designed for depth control of screw and a V-shaped anvil adopted for automatic centering of screw cap.



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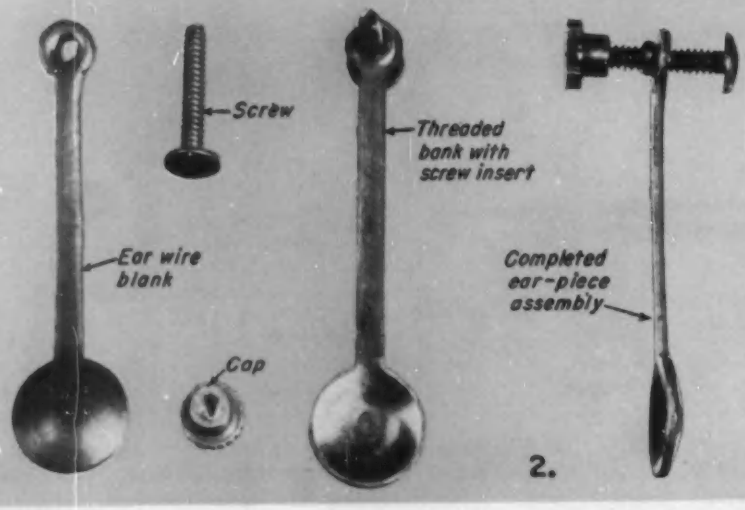
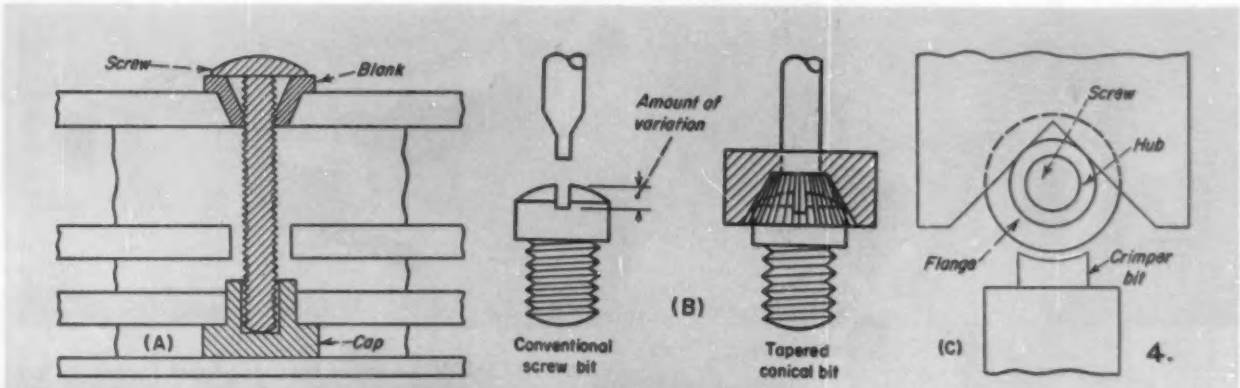
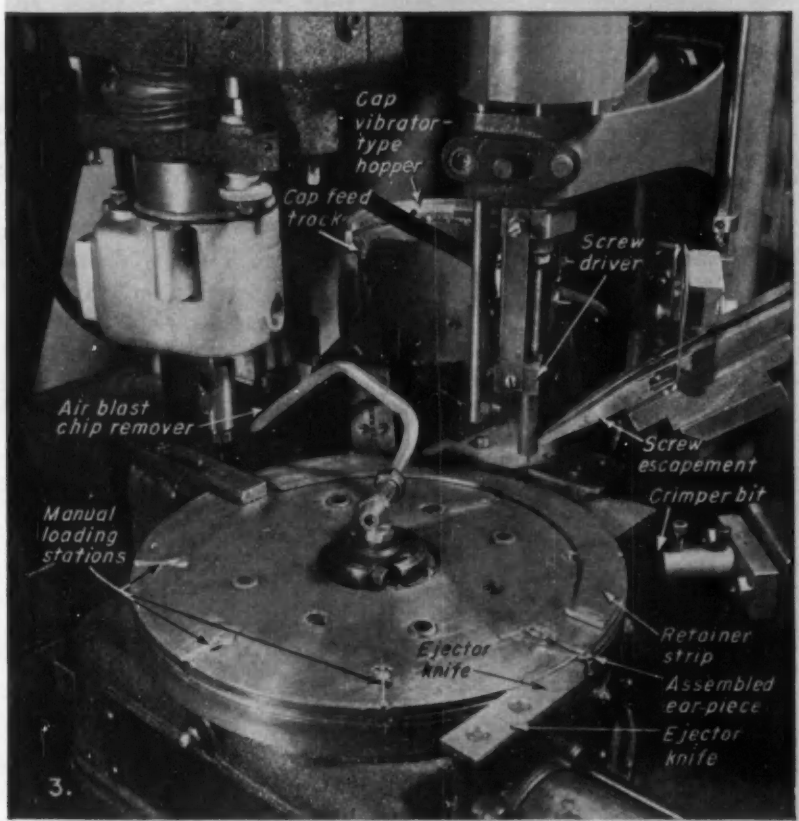


2.

1. Basic structure of assembler is modified floor-model screw driver unit. Original screw driver unit table was replaced with larger table welded to upright driver member; steel side braces were added for support. Alternative would have been to use bench-model screw driver unit, only slightly less in cost, and to construct complete table and supports. To provide dial feed, air operated indexing table was selected because of simplicity and economy. Other possible choices were cam-operated table—relatively expensive and of accuracy not needed for job—and





crank-actuated table which require outside linkage. To operate machine, attendant presses two-way foot lever, actuating screw driver, tapper and crimper. Tapper and crimper automatically return; screw driver returns on reverse press of foot lever.

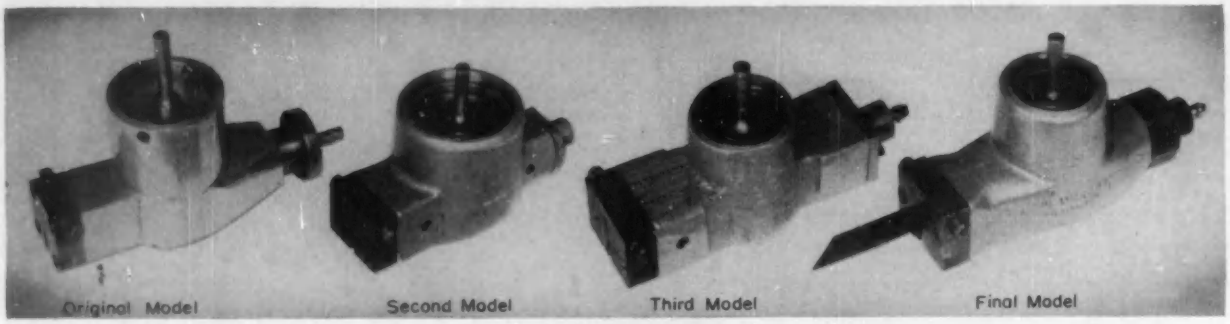
2. Ear-piece assembly parts. Smooth head of screw required design of conically tapered driver head for accurate insert control. Varying sizes of caps used in assembly created feed and crimping problem, and resulted in V-shaped anvil in lower section.

3. Use of 8-station indexing table was determined by the spacing required between tables for tools and the working room most practical for operator. Four stations engage in assembling —tap, cap feed, screw insert and crimp; fifth station ejects completed assembly. Three stations are provided for manual loading of blanks. Less than three stations would fail to give sufficient working room. More than three stations would hamper tool operation because of closer spacing between stations, and a larger size table would make unit less compact. Caps were fed from a vibratory hopper; chute needed smooth point-to-point transition to prevent jamming of small flange caps.

4. (A) assembly in nest prior to ejection with three-section plate shown. Originally, screw was partly inserted through threaded hole, cap slipped on, and screw insertion completed. Screw adjustment is now accomplished in one motion—cap is fed to nest and aligned with blank, with screw then fully inserted. (B) Conventional driver bit failed to insure constant insert depth because ear piece screw heads are not slotted. Conically tapered driver, center, was developed making peripheral contact with head; variation in a screw insert depth is eliminated. (C) Cap is automatically centered by V-shaped anvil regardless of flange diameter. Cap is thus crimped into screw at three points, providing minimum surface contact. Crimping bits vary in shape according to hub thickness—rounded bit is used for thin hubs; for thicker hubs a V-shaped bit applies crimping force at two points along axis of hub.

More commonly known developments in mechanized assembly have been in such fields as lamps, radio tubes and electronic devices, food processing and automotive components. The Tinkertoy system, discussed at length in the December 1953 issue starting on page 134, was a good example; a further development of this idea by ACF Industries, is described in this issue on pages 198.

But the machine described here demonstrates the value of automatic assembly even in the jewelry findings field. Incidentally, the cost saving on the operation described here was 28 per cent.



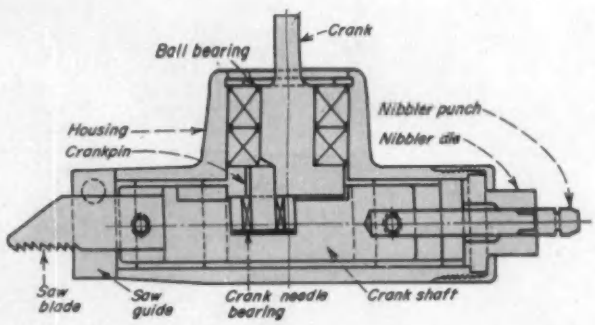
Dual Purpose Tool Attachment

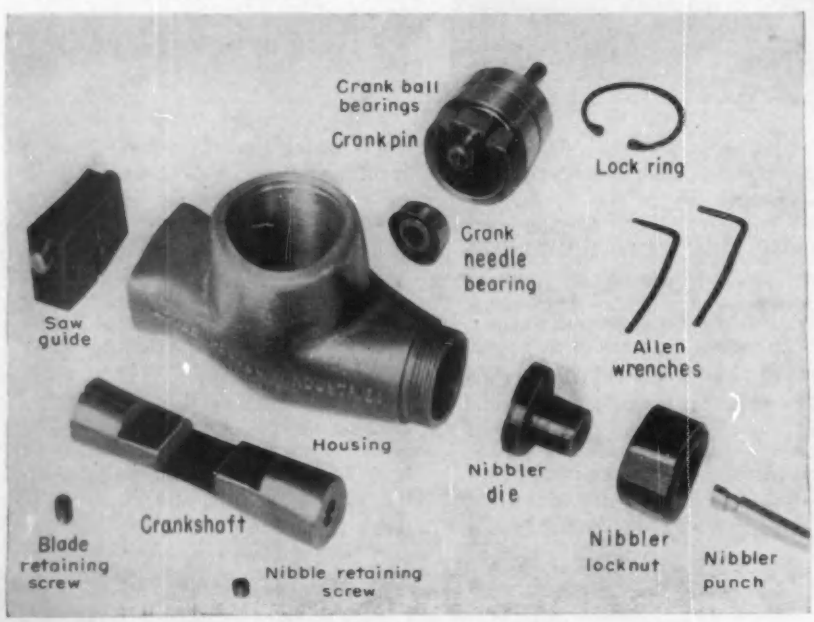
An electric drill attachment which can saw and nibble has been produced by Little Beaver Industries, Willoughby, Ohio; unit weighs 1¾ lb. and is approximately one-third the size of comparable attachments.

Design was undertaken to provide a tool for heating and plumbing installation. Close quarter and overhead work required the unit to be compact, light weight and sturdy.

Tool was required to perform two functions–saw and nibble. Completed design does either when crankshaft of attachment is chucked in drill.

FIRST DECISION was use of bearing-type cam follower to take advantage of long bearing life; a ball bearing was chosen. To fill bore, a tapered roller bearing was selected in preference to cylindrical fill-plug on basis of lower cost. **Original model,** a 2-piece assembly, needed substantial machining; also, a large number of screws were required. **Second model** was 1-piece unit; neck height was reduced as tapered bearing was replaced by roller bearing. **In third model,** smaller roller bearing was used, giving reduced neck diameter. **In final design,** attachment was molded to fit hand; two ball bearings were placed in bore to carry side thrust, and small needle bearing was adopted for cam follower.





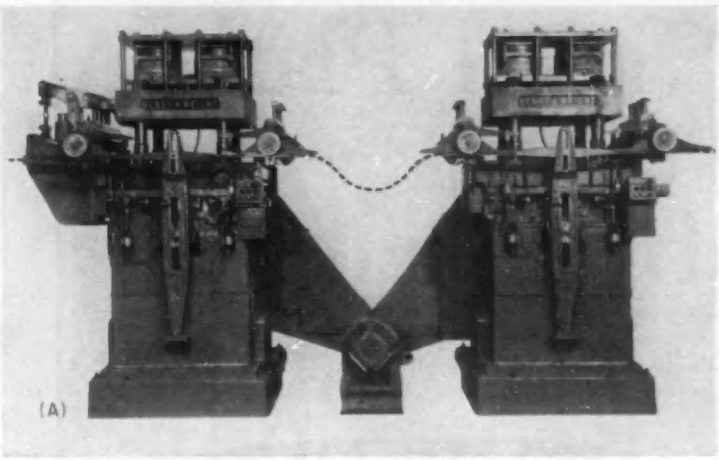
THREE METHODS were considered for translating rotary into reciprocating motion: gearing, eccentric lever or crank. Gearing was rejected because of tooth wear and relatively high initial cost. Eccentric levers involved too many parts requiring support, increasing possibility of breakdown. Stroke of unit was set at ¼ in., satisfactory for tooling work, and short enough to permit use of needle bearings.

ATTACHMENT has few parts, all of small size. Saw blade is held by set screw. Guide serves to brake saw stroke in case of lateral loading, preventing displacement of crankshaft. Other tools may be operated–file, rasp, gouge, chisel and hammer.

Tandem Dieing Machine

To simplify die design and facilitate higher production a tandem dieing machine unit has been developed by Henry & Wright, Hartford, Conn. for use with progressive dies. Long dies for complex parts are subject to thermoexpansion, reducing control of clearance between punch and die. Heavy masses of large presses required in conjunction with long dies restrict production speed.

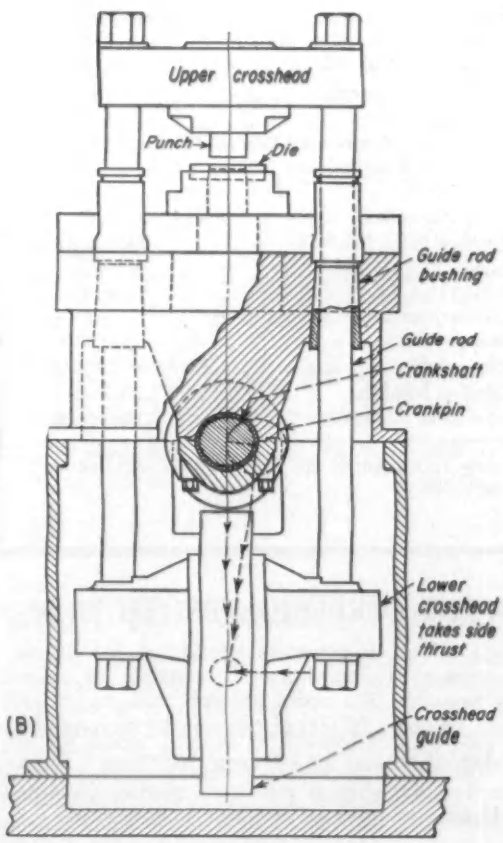
Tandem unit permits cutting length of die in half; use of two machines reduces mass of individual reciprocating elements, permitting faster operation.

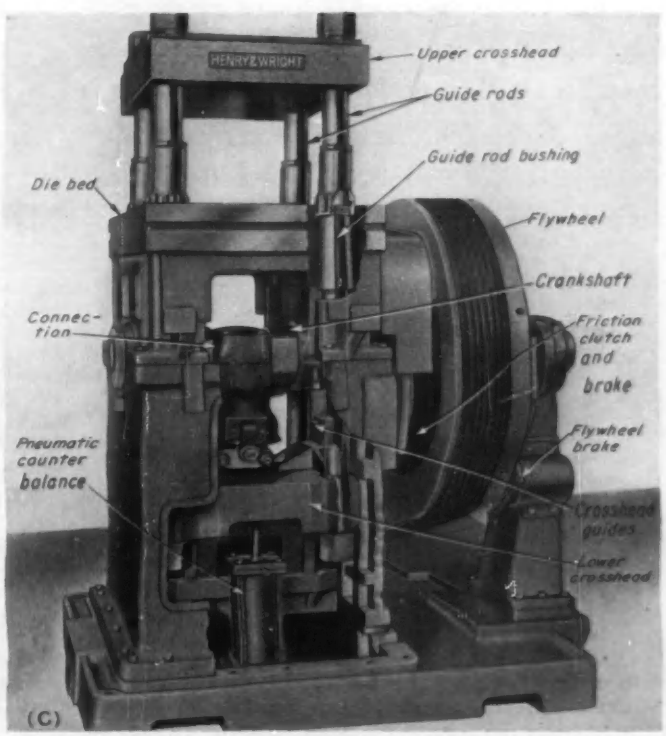


(A) Two units are driven by a common d-c variable-speed drive; operation can be controlled at either machine. In one tandem application on motor laminations, one machine stamps rotors, the second stators. Flexibility is achieved as each die may be individually changed.

(B) In original design of units employed in the tandem machine a platen with four guide rods was selected rather than the conventional C-frame to obtain greater work area. Lower crosshead absorbs horizontal force to give closer control of alignment between punch and die. Flywheel and crankshaft were located beneath the die bed to minimize vibration effects and adjustable tapered bushings compensate for wear in guide rods.

(C) Springs formerly used to absorb inertia forces of reciprocating parts have been replaced by an adjustable air cylinder. An air-operated multiple-disc clutch is installed on flywheel, replacing a positive mechanical clutch for easier die setting.





Nickel Plating by Chemical Reduction

. . . often results in greater corrosion protection and more uniformity in plate thickness over surface areas of intricate parts than can be accomplished with electroplating. Cost savings are effected by applying a hard nickel plate to soft base metals, such as aluminum, copper and bronze, or to thermosetting plastics. Close-tolerance machined parts can be plated without requirement for post-machining or finishing, provided care is exercised in setting up the plating bath. Post-plating grinding and machining operations can be performed if a little care is taken. Suggestions are given for conditioning the base surface for plating that will stand up in the various corrosive atmospheres.

W. J. CREHAN
Chief Engineer, Kanigen Div., General American Transportation Corp.

Table I—Physical Properties of Chemical Nickel Plate

Property	As Plated
Hardness	450–500 Vickers 49 Rockwell C
Adhesion to Base Metal	Excellent (Function of pretreatment)
Coefficient of Expansion.	13×10^{-6} in./in. (C) 7.22×10^{-6} in./in. (F)
Resistivity	60 micro ohm
Density	7.85
Melting Point	1675 F

Table II—Corrosion Properties of Chemical Nickel Plate*

Atmosphere	Penetration (mils/year = in./year $\times 10^{-3}$)
Anhydrous Thionyl Chloride	0.032
Photographic Developer	27 day test—No attack
Photographic Hypo	27 day test—No attack
Insectisol	0.008
Fluorophosphoric Acid	1.56
50% Tanning Solution (Koreon)	0.048
Monochloracetic Acid	Not recommended
Methyl Alcohol	0.013
5% Acetic Acid	0.791
1% Sulfuric Acid	1.12
Distilled Water	0.029
5% Tide Solution	0.037
Glucose (five grades)	No attack
Stearic Acid (70°C)	0.02
5% Citric Acid	0.97
Gasoline	0.022
Petroleum Sour Crude	0.0012
Phosphoric Acid 85% (140°F)	Not recommended
5% Ammonium Phosphate (140°F)	0.8
3% Calcium Chloride	0.215
3% Sodium Chloride	0.0165
5% Cyanide	0.38
Ammoniated Ammonium Nitrate Solution	0.13
Ammoniated Ammonium Nitrate Vapors	0.75
45% Lactic	0.29
5% Sulfuric Acid	1.83
Refinery Brine Solution	No attack
Carbon Disulphide	No attack
Benzyl Chloride	0.05
Lemon Juice	0.23
Orange juice	0.013
Nitric Acid	Not recommended
Odorless Naphtha	No attack
Petroleum White Oil	No attack

*All tests were made on polished steel plates totally immersed in the bath with no aeration or agitation.

PLATING BY CHEMICAL REDUCTION, using the Kanigen process, is carried out by immersing the part to be plated in a bath heated to 210 F ±10 F. Nickel plates out at a uniform rate of about 0.001 in. per hr on all properly prepared catalytic surfaces in contact with the bath. Physical properties of the plating are shown in Table I. A flow diagram of one of the systems employed for plating by chemical reduction is shown in Fig. 1.

NICKEL FOR CORROSION PROTECTION

In design, nickel is generally considered for its corrosion resistance properties and is available in several forms—as wrought, 300 series stainless and monel. All of these can be clad. Nickel plating can be accomplished by electrodeposition and by chemical reduction. Corrosion properties of chemical reduction plating are listed in Table II for a number of corrosive atmospheres.

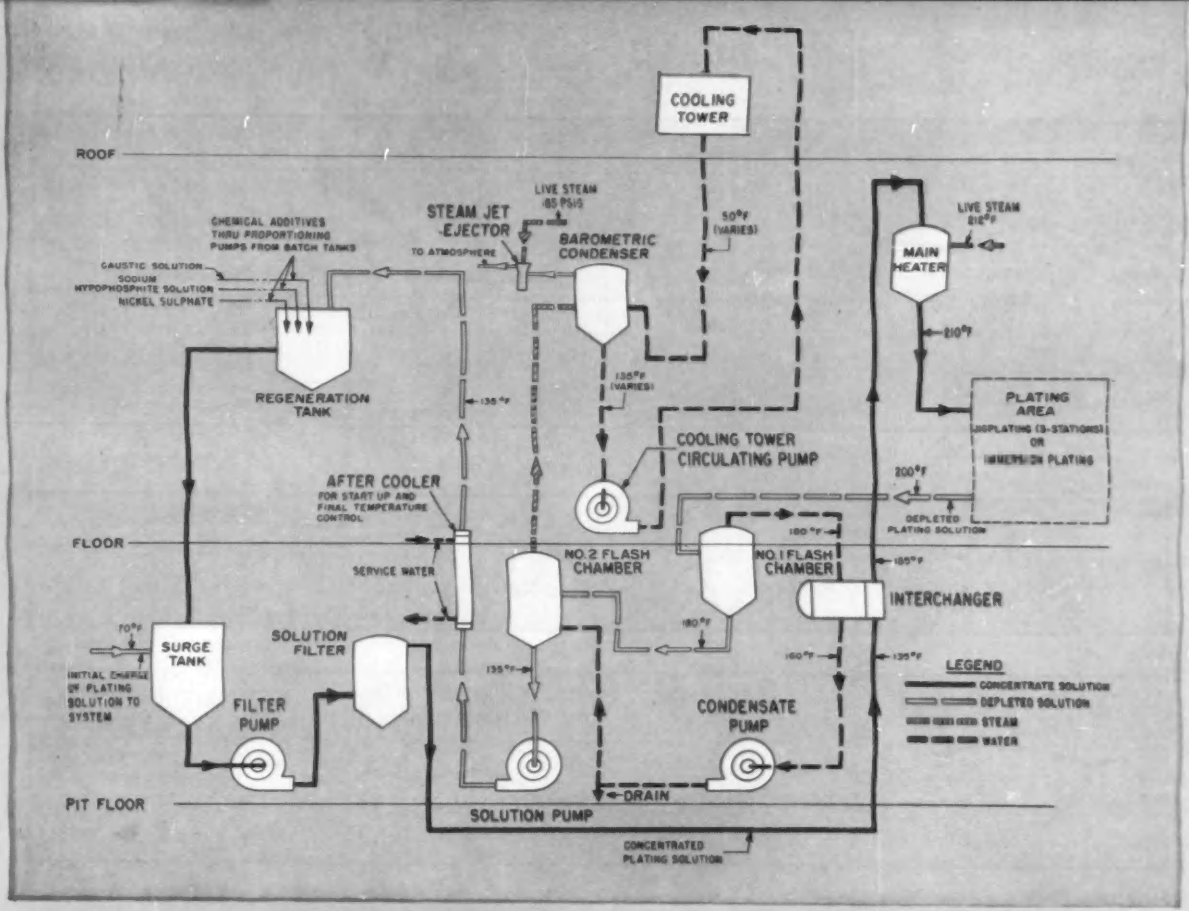


Fig. 1—Flow diagram of system used in nickel plating by chemical reduction. This arrangement is used by American Locomotive Co. in applying Alcoplate to parts. Alcoplate is a slightly modified adaptation of the Kanigen Process.

Table III—(A) Costs of Materials of Construction Before Plating

Material	Thickness of Material, in.				
	1/16	1/8	1/4	3/8	1/2
	cost, dollars per sq. ft.				
Carbon Steel	0.12	0.25	0.50	0.75	1.00
Ni Clad 20%	1.64	3.29	6.59	9.87	13.18
316 Stainless	1.74	3.48	6.97	10.45	13.94
Monel	3.15	6.31	12.63	18.96	25.28
Solid Nickel	2.49	4.99	9.99	14.99	19.99
Carbon Steel plus 3-Mil Kanigen Nickel*	3.08	3.20	3.45	3.71	3.95

Note: Cost based on mill prices, Oct. 11, 1954, with representative extras.
*On a custom plating basis.

Table III—(B) Costs of Materials of Construction as Plated by Kanigen

Material	Fabrication Factors	Thickness of Material, in.				
		1/16**	1/8**	1/4**	3/8	1/2
		Cost, dollars per sq. ft				
Carbon Steel	1.00	0.63	1.27	2.54	3.81	5.08
Ni Clad 20%	1.30	2.31	4.62	9.24	13.85	18.48
316 Stainless	1.20	2.35	4.70	9.41	14.129	18.83
316 Stainless Clad 20%	1.25	1.99	4.01	8.00	12.01	16.00
Monel	1.25	3.85	7.67	15.39	23.03	30.78
Solid Nickel	1.25	3.21	6.42	12.86	19.24	25.61
Carbon Steel plus 3-Mil Kanigen Nickel*		3.60	4.22	5.49	6.77	8.84

Fabricated cost=Material cost+pounds×20¢×fabrication factor
*Custom Plating Basis
**Fabrication factors to ¼ in. thick are higher on thin sheets than those shown. Actual comparisons must be made.

WHEN TO CONSIDER THIS METHOD

Until plating by chemical reduction was developed, specifications could only call for electroplating of parts fabricated of common metals. On intricate parts, the use of plating became impractical and sometimes impossible. Special anodes were needed to "throw" into areas of difficult access; and to achieve adequate throwing power, more nickel than needed was deposited on some areas to insure a deposit of sufficient nickel on all surfaces. This sometimes required subsequent double machining of the part.

Plating by chemical reduction will not supplant electroplating in all cases but often exhibits its chief advantage in applications where the shape is complex. It is this use of the process, where electroplating is unsatisfactory, that makes a cost comparison between the two methods

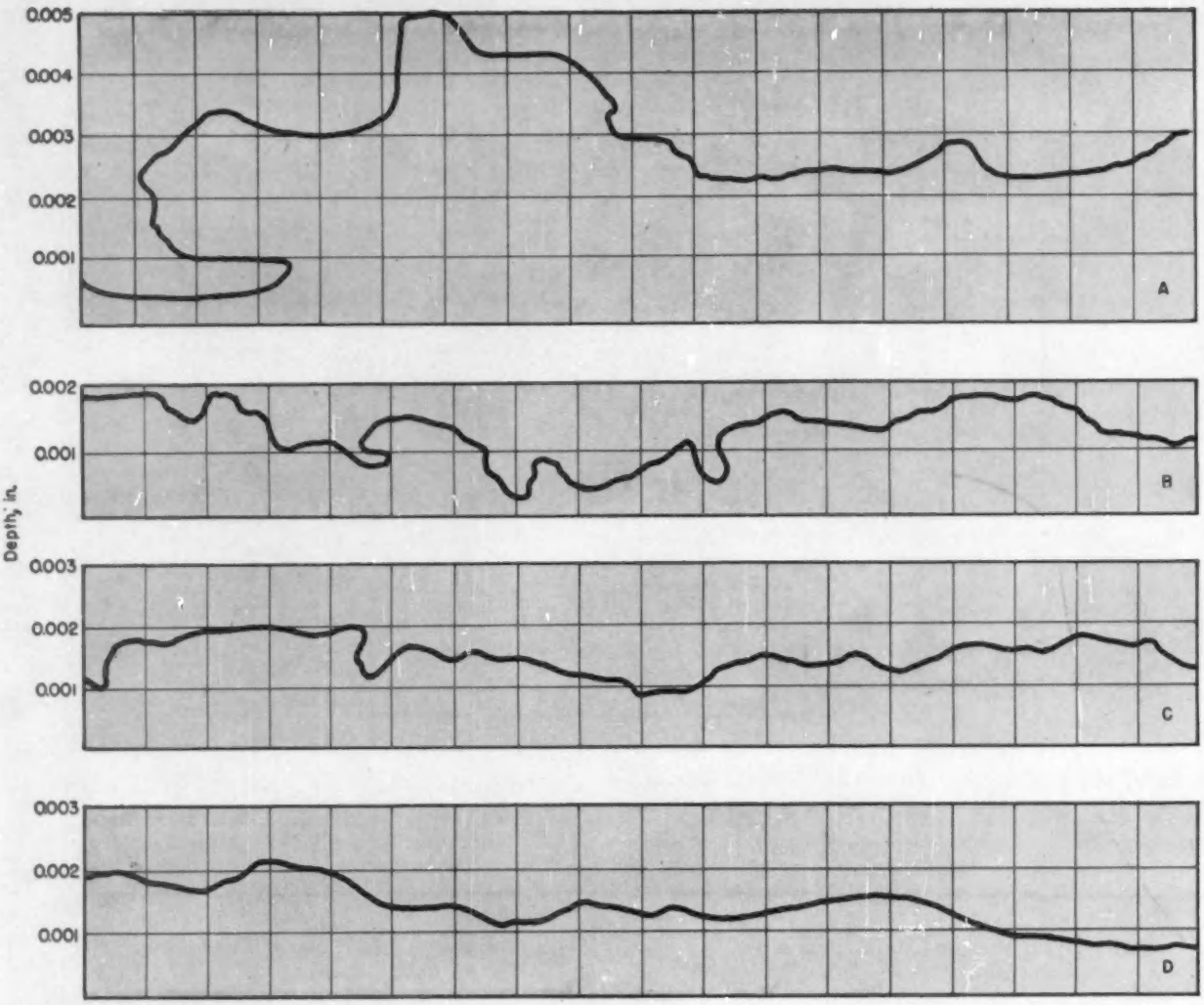


Fig. 2—Surface profiles of low carbon steels show results obtained by blasting with four different materials. No. 25 steel grit was used on Surface A; the large size of this blasting medium leaves large indentations and presents a poor surface for plating. Surface B, blasted with No. G-50 steel grit is a relatively better surface for plating. Surface C, where No. G-80 cast iron grit was used, presents a good plating surface while Surface D, blasted with No. S-110 steel shot approaches the ideal surface for plating.

difficult. Some typical costs of materials plated by the Kanigen process can be obtained by reference to Table III.

SURFACE PREPARATION FOR PLATING

Condition of the surface presented to the plating bath is of prime importance, since this governs the quality of plate. A smooth, clean surface is necessary for quality plating. All welds should be ground smooth and be free of pits or blow holes; all weld spatter should be removed. The entire surface should be uniformly fine blasted to remove scale, machined, or otherwise given a reasonably uniform finish. Care must be exercised in using sand, shot or grit blasting, both in the manner of blasting and selection of fineness.

Corrosion resistant requirements cannot be met with nickel plating of 0.001 in. on a surface which has been prepared by a very coarse blasting. Coarse blasting produces a rough surface with relatively great heights and depths besides undercutting and tearing of the surface. This is represented at (A) in Fig. 2. Use of No. 25 grit blast produces hills and valleys varying at least 0.005 in., allowing the possibility of incomplete coverage. Complete coverage is further lessened by the undercutting which may produce gas pockets that will not be in contact with the plating solution.

An examination of (B), (C), and (D) of Fig. 2, shows that a satisfactory blasted surface is not obtained until a fine steel shot is used. The S110 steel shot is somewhat comparable in particle size to the G50 grit (Fig. 1B); S110 shot analyzes 100 per cent through a No. 30 screen and 65 per cent min. on a No. 50 screen with 25 per cent max through a No. 80 screen. G50 grit analyzes 100 per cent through a No. 25 screen, 65 per cent min. on a No. 30 screen and 25 per cent max through a No. 80 screen. A smoother surface is produced by the S110 steel shot than with either G50 or G80 grit, because the grits tends to tear and undercut.

If a machined surface is to be reduction plated, care should be taken to produce it with sharp tools so the surface is cut and not torn. All tears are focal points for plating faults.

In general, if maximum adhesion is desired, some fine "tooth" must be left on the surface; yet even polished surfaces show excellent adhesion. For maximum corrosion resistance, the surface should be as smooth and as homogenous as possible.

It will usually be less costly to design for a minimum of masked surface on parts requiring only partial plating. This is not always easy to accomplish; but when considering the ability of the bath to plate to a uniform thickness on all surfaces, many opportunities occur to either machine to dimension and then plate, or to plate all over and machine to dimension those critical parts where no plating is required.

MECHANICS OF THE PLATING BATH

Even with 100 per cent throwing power there are certain bath limitations to consider. Hydrogen gas is evolved in the plating reaction and may become trapped in inverted pockets, thus preventing the solution reaching such areas. When intricate parts are handled, many venting problems occur. These can often be overcome by proper design, and it is important to keep in mind the necessity of having the solution in constant contact with the surface to be plated.

Another important consideration is the amount of plated surface to be specified on a part. In immersion tank plating, costs are based on total area to be plated.

Some parts, such as closed vessels, which do not lend themselves to tank immersion but which require plating on interior surfaces may be plated on a jig. The vessel must be considered as the plating tank with solution being pumped through it, preferably entering through a bottom opening and overflowing through some top opening. The interior can be pretreated in the jig. Care must be exercised to produce a part with no gas pockets. Some closed vessels can be jigged on a set of rotating rolls. The design must allow solution to enter through an opening at one end on the horizontal axis and be removed by overflowing. There must also be provision for complete drainage of all cleaning and plating solutions, such as a side outlet or an opening at one end along the periphery.

BASE MATERIALS SUITABLE FOR PLATING

Plating by chemical reduction has been applied experimentally to almost every commercially used metal, as well as thermosetting plastic materials. More experience has been obtained and more information is available for reduction plating on steel than for any other metal, but this does not mean that other metals cannot be nickel-plated by this process.

The higher steel alloys generally take more care in pretreatment for plating to insure good adhesion. Stainless steel can be reduction plated; the main reason for plating being to eliminate the galling tendencies of the 300 series.

Plating can be done on cast irons of various types, but such materials present difficulty. This difficulty is not because a good homogenous coating cannot be plated but rather because rough castings will usually have one or more holes or surface defects that mar the plate. The plating properties of ductile iron are generally superior to grey iron.

There are many applications for nickel plated aluminum parts, since a combination of light weight and hard coating is obtained. Also, plating on aluminum can provide a surface to which other parts may be more readily joined by soldering or brazing methods.

The plating can be easily applied to copper, brass, and bronze, affording wear protection and added corrosion protection. In some cases bimetallics will cause galvanic effects while plating is in progress, adversely affecting the coating of one of the metals in the couple. Reduction nickel is slightly less noble than pure nickel as checked in a potassium chloride cell; however, this relation may not hold true in all types of corrosive media. The plating is cathodic to aluminum, so care must be exercised in its application to aluminum for use in a corrosive environment. The protection will be good on a complete nonporous coverage and will hold up satisfactorily barring physical damage.

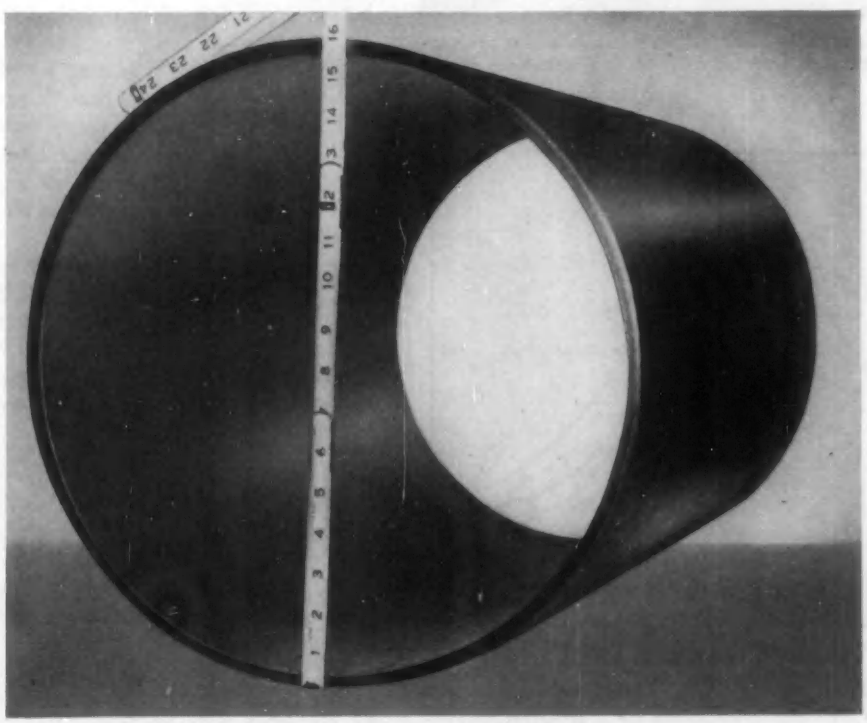


Fig. 3—Chemical reduction permits the plating of any part which liquid can reach. Here is a 16 in. cast steel pipe that has been plated on the outside as well as the interior.

APPLICATIONS

Cylindrical parts, such as hydraulic cylinders, can be reduction plated since no internal anodes are necessary. Some applications where the process has been used to good advantage are for valves, tanks, cylinders, nuts, bolts, screws, steel balls, pumps, compressors, and thermoseting plastics. Valves of various types have been internally coated, allowing the use of steel or iron bodies with the corrosion protection being provided by the plating. In Fig. 3, a 16 in. cast steel pipe is shown plated. The process is also applicable to small parts, Fig. 4.

Because of its 100 per cent throwing power and its build-up at a uniform rate, there are many applications on parts machined to close tolerances. Close tolerances on plated parts can be held without the requirement of finished machining. Costly parts which have been overmachined can often be salvaged by reduction plating without requiring any subsequent machining operation.

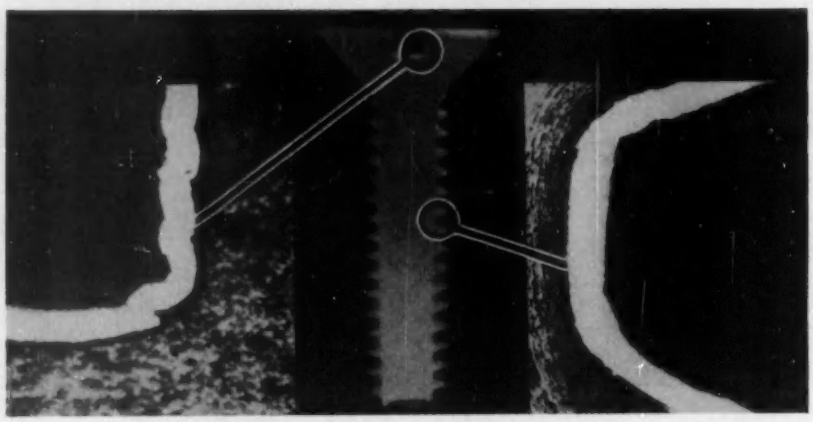


Fig. 4—Uniformity of thickness, a characteristic of the chemical reduction process, permits the nickel-plating of many small parts with no appreciable dimensional change caused by irregular build-up.

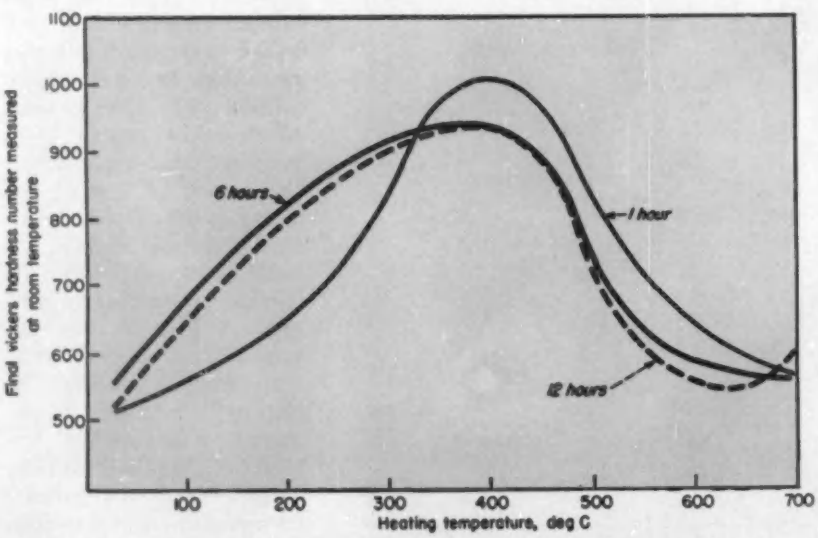


Fig. 5—Heat treatment curves of nickel-plating by chemical reduction. Data were obtained by heating the part in an inert atmosphere and holding at a specified temperature for 1, 6, or 12 hours. The parts were cooled slowly to 200 C, then removed from the oven. All measurements, taken on the top surface of 0.005 in. plating on cold rolled steel, were made at room temperature.

PERMISSIBLE POST-PLATING OPERATIONS

Many operations can be performed on parts plated by chemical reduction, including soldering or brazing to the plating, and heat treating the plated parts.

Highly stressed members can be relieved by heating in an oven at 400 F for 2 to 4 hr. This heating time will vary with the base metal, shape, and thickness of plate.

A wide range of hardness results with heat treatment, as shown in Fig. 5. The plating can be ground and, with proper care, machined, even though it is very hard. Grinding is generally preferred, since chipping by a cutting tool may nullify the corrision protection of the coating.

LIMITATIONS

It generally is not economical to plate thin steel, thus replacing thin, solid, corrision-resistant alloys. Chemical reduction plating cannot be used on parts which are subsequently welded unless the areas to be welded are masked out. Otherwise a nickel overlay or a line of demarcation between the weld nickel and the plating would be required. Welds made on plated areas may be embrittled by picking up phosphorus from the plating. Since the plating process produces a hard, low ductile coating, it is not suitable plating to use where there will be considerable flexing of the part—such as in forming or drawing operations. All applications necessitating subsequent drawing or forming should be tried out experimentally before specifying nickel plating of any type.

Chemical reduction plating is not always applicable where heat is encountered, particularly where any rubbing contact exists. The hot hardness is low, so applications involving heat should be investigated for applicability.

In corrosive environments, reduction plating is not a good choice if the pH is below 5. Tables of nickel corrosion resistance published by the International Nickel Company can be used as a general guide for selecting nickel as a plating material.

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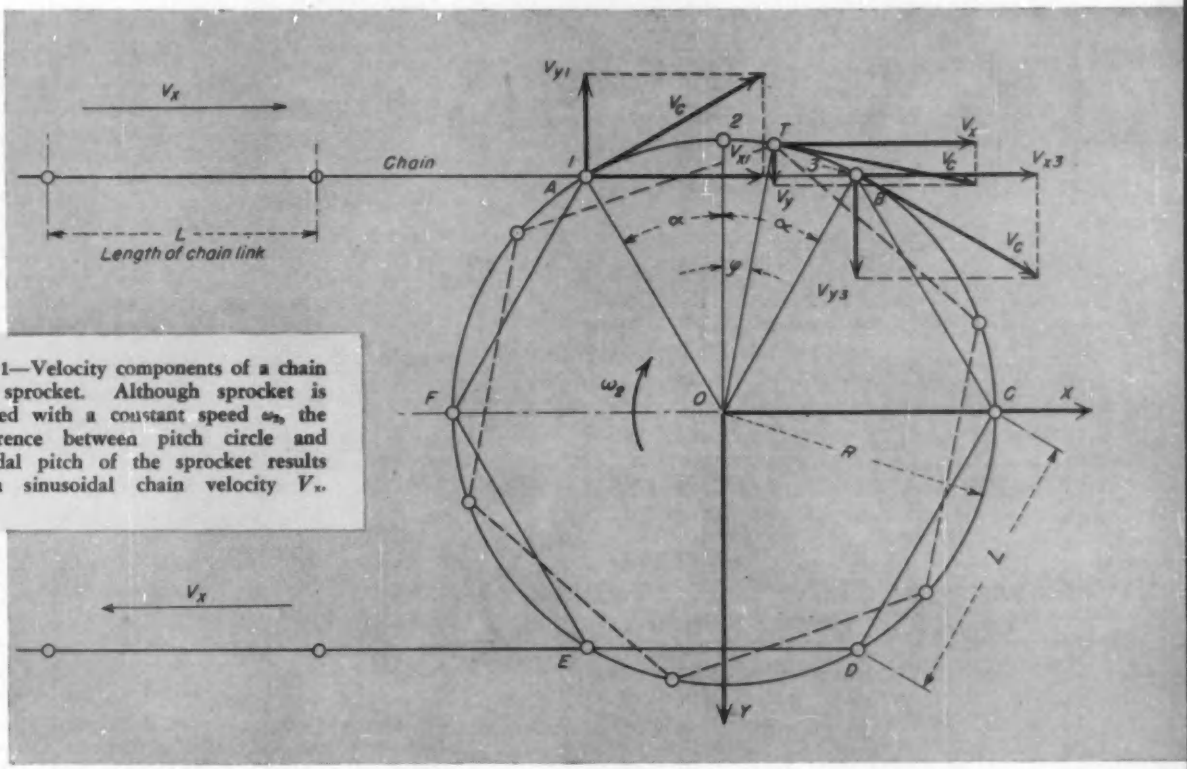

Fig. 1—Velocity components of a chain and sprocket. Although sprocket is rotated with a constant speed ω_2, the difference between pitch circle and chordal pitch of the sprocket results in a sinusoidal chain velocity V_x.

Eliminating Pulsations in CHAIN DRIVES

Analysis of chain motion, factors inducing pulsations and methods of calculating dynamic loads. Equations for design of an equalizing mechanism, and a method for laying out equalizer cam profiles.

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A FACTOR limiting the operating speed of conveyors or elevators is the pulsation in chain velocity caused by the difference between the true pitch circle and the chordal pitch of the polygonal sprocket wheel. The resultant cyclic accelerations and decelerations create dynamic loads which increase rapidly with increases in velocity and become quite high for units using long-pitched chains.

The pulsations can be reduced by increasing the number of teeth in the driving sprocket; however, this is not always permissible since:

1. Length of chain links are usually determined by dimensions of aprons, buckets or other members.

2. Chains with short links are heavier and costlier to produce and operate than chains with longer links but of equal capacity.

3. If sprocket diameter is increased to maintain the pitch, sprocket rpm must be decreased to maintain linear velocity, thus requiring a ratio change in the gear drive.

A practical solution is the use of an equalizing mechanism which feeds a variable rotary motion to the sprocket synchronized to the inherent pulsations of the chain. This produces a constant linear chain velocity and eliminates the dynamic loads.

The action of a chain as it runs over a sprocket can be compared to a non-slipping thread running over a regular polygonal prism. Fig. 1 illustrates the variation in chain

Fig. 2—Chain supported by guide frames is tangent to inscribed circle (A) and to circumscribed circle (B) of a four-toothed sprocket. Use of a guide frame prevents sag but increases angle γ resulting in higher dynamic loads.

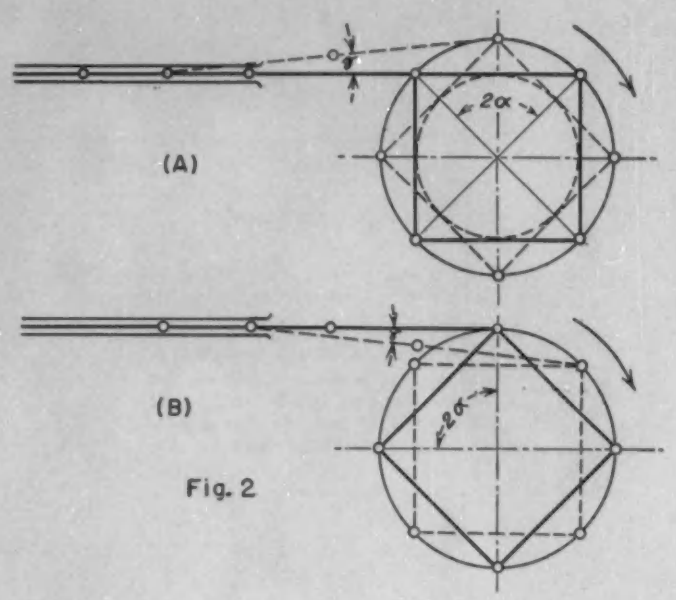


Fig. 2

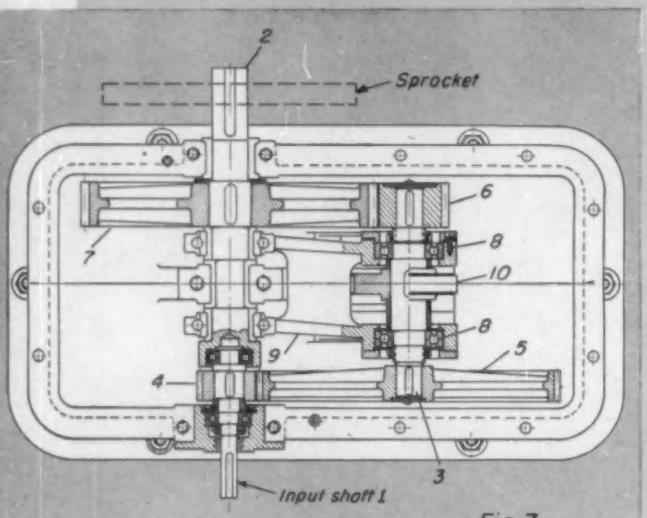
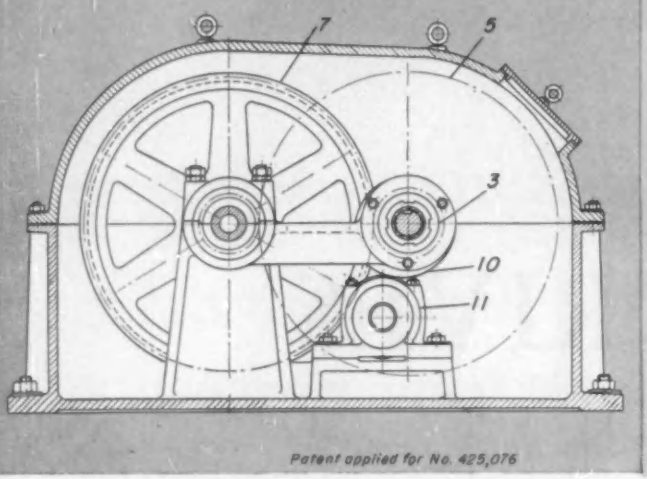


Fig. 3



Patent applied for No. 425,076

Fig. 3—An equalizing mechanism that also functions as a speed reducer. Power is transmitted from shaft 1 to 2 through two sets of gears (4 and 5, 6 and 7) which also produce the required reduction ratio. Shaft 3 rotates in bearings located at the end of arm 9, and 9 oscillates about shafts 1 and 2 activated by cam 10 keyed to shaft 3. Thus, the cam, shaft 3, and gears 5 and 6 rotate as a unit. The cam rides on a circular idler roller 11 and because of the equilibrium of the forces, maintains positive contact with it. The oscillation of 9 causes the entire gear system to operate as a planetary gear drive with 4 and 7 acting as sun gears and 5 and 6 as planet gears. As a result, gear 7 and with it, the sprocket wheel, receive an additional alternating angular velocity with a period of cycle equal to the time required for 6 to make one revolution. This period is also equal to the time needed for a chain link to travel a distant equal to its length; therefore, the ratio between the number of teeth of 6 and 7 is equal to the number of teeth on the sprocket wheel.

velocity caused by a sprocket revolving with a constant angular velocity. The apexes of the prism A to F move with a constant circumferential velocity V_c. Point 1 which coincides with A represents the first contact of chain and sprocket tooth. As point A moves along a circular path to B, it leads the chain from A to B during which apex F moves to point 1 through a similar path.

At any point T, the circumferential velocity V_c can be resolved into two components V_x and V_y.

$$V_x = V_c \cos \phi = \omega_2 R \cos \phi \quad (1)$$

$$V_y = V_c \sin \phi = \omega_2 R \sin \phi \quad (2)$$

The angle ϕ varies from $-\alpha$ to $+\alpha$ and is equal to zero at point 2. Thus, the minimum value of V_x which occurs at points 1 and 3 is equal to

$$(V_x)_1 = (V_x)_3 = \omega_2 R \cos \alpha \quad (3)$$

and its maximum value at point 2 is

$$(V_x)_2 = \omega_2 R = V_c \quad (4)$$

The acceleration of the chain is positive from points 1 to 2, and negative from 2 to 3, after which the next apex engages the chain and repeats the process with an instantaneous change in acceleration from a negative to a positive value.

In the y-direction the minimum chain velocity occurs at point 1, and the maximum at point 3.

$$(V_y)_1 = -\omega_2 R \sin \alpha$$

$$(V_y)_3 = \omega_2 R \sin \alpha$$

At point 2 the velocity component equals zero.

The chain pulsates with a period equal to

$$t = \frac{60}{N_2 n} \text{ sec}, \quad (5)$$

where N_2 equals sprocket speed in rpm, and n equals the number of teeth on the driving sprocket. The frequency of this pulsation is

$$f = N_2 n/60 \text{ pulses per sec} \quad (6)$$

If the frequency is close to the natural frequency of the system or to one of its harmonics, and if the chains are not supported in the y-direction, the amplitudes can reach a dangerous magnitude.

The acceleration of the chain in the x-direction is

$$a = \frac{dV_x}{dt}$$

Introducing the expression, $\phi = \omega_2 t$ and the value of V_x from Eq (1), the acceleration becomes

$$a = \omega_2 R \frac{d}{dt} (\cos \omega_2 t) = - \omega_2^2 R \sin \phi$$

Therefore

$$a_1 = \omega_2^2 R \sin \alpha$$
$$a_3 = - \omega_2^2 R \sin \alpha$$

The instantaneous increase in chain acceleration when the new sprocket tooth engages the chain is equal to

$$a_1 - a_3 = 2\omega_2^2 R \sin \alpha \quad (7)$$

The average chain velocity which is the operating conveyor velocity is

$$V_o = N_2 nL/60 \text{ in./sec} \quad (8)$$

and the angular velocity of the sprocket is

$$\omega_2 = \frac{\pi N_2}{30} = \frac{2V_o\pi}{nL} \text{ rad/sec} \quad (9)$$

Introducing $\sin \alpha = L/2R$ and Eq (9) into Eq (7)

$$a_1 - a_3 = \frac{4}{L}\left(\frac{V_o\pi}{n}\right)^2 \text{ in./sec}^2 \quad (10)$$

resulting in a dynamic force which is instantaneously applied to the chain:

$$F_{dyn} = \frac{\Sigma W}{g}\left(\frac{4}{L}\right)\left(\frac{\pi V_o}{n}\right)^2 \text{ lb} \quad (11)$$

where ΣW is the sum of the weight of all linearly moving parts and the load of the conveyor. Because of the elasticity of the members of the conveyor, the actual dynamic load will be smaller than the calculated dynamic load; this difference increasing with length of the conveyor.

Since F_{dyn} is applied instantaneously, the stresses in the chain members are proportional to twice its value, and since it is a pulsating force, the fatigue strength of the chain materials must be considered.

Increasing the critical cross-section of chain links to make the chains stronger helps only partially since this increases the weight of the chain (and thus the dynamic load on it), and the manufacturing costs.

In some conveyors, the chain is supported by a guide frame, Fig. 2. Thus the chain is not a connecting rod of infinite length and the dynamic load increases approximately 20 per cent.

Design of an Equalizing Mechanism

The pulsations in chain motion described above can be equalized by feeding a variable cyclic motion to the sprocket. In comparison to other types (see page 168) the equalizing reducer shown in Fig. 3 has these advantages.

1. Positive equalization of conveyor velocity.
2. Acts simultaneously as a speed reducer and a chain-motion equalizer through the same gears.

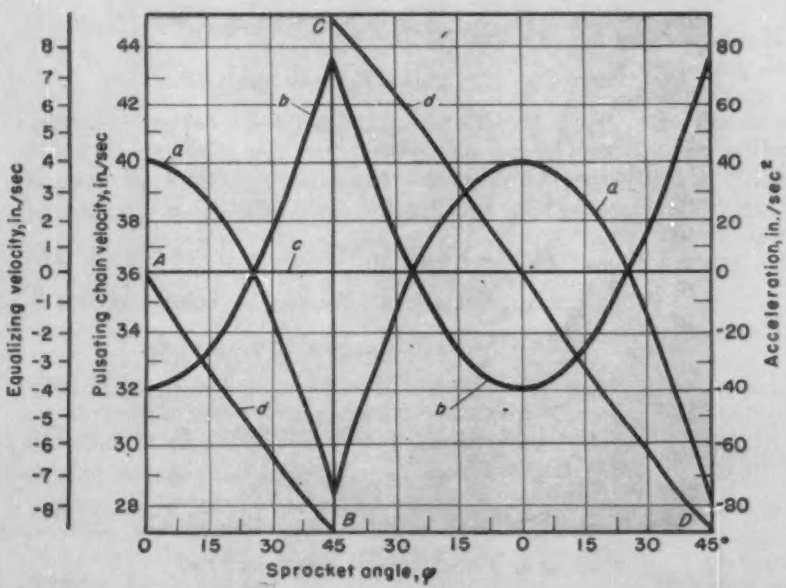


Fig. 4—Velocity and acceleration chart of chain driven by a sprocket with four teeth. Chain velocity without an equalizer (curve *a*) is equalized to curve *c* by the input of variable motion from an equalizer (curve *b*). Curve *d* shows the acceleration of unequalized chain motion.

SYMBOLS

- ω_1 Velocity of shaft 1, rad/sec
- ω_2 Velocity of shaft 2 (and sprocket) when arm 9 is considered stationary, rad/sec
- ω_3 Velocity of shaft 3 (and cam) when arm 9 is considered stationary, rad/sec
- ω_α Variable angular velocity of arm 9, rad/sec
- ω_2' Additional variable velocity of shaft 2 induced by oscillatory motion of arm 9, rad/sec
- ω_3' Additional variable velocity of shaft 3 induced by oscillatory motion of arm 9, rad/sec
- ω_e Variable velocity of shaft 2 required to produce a constant chain velocity. $\omega_e = \omega_2 + \omega_2'$
- ω_e Variable velocity of shaft 3 when equalizing reducer is operating. $\omega_e = \omega_3 + \omega_3'$
- b Length of arm 9 equal to the distance between axes of shafts 1 and 2, and shaft 3, in.
- D_4, D_5, D_6 and D_7 Pitch diameters of gears 4, 5, 6 and 7, in.

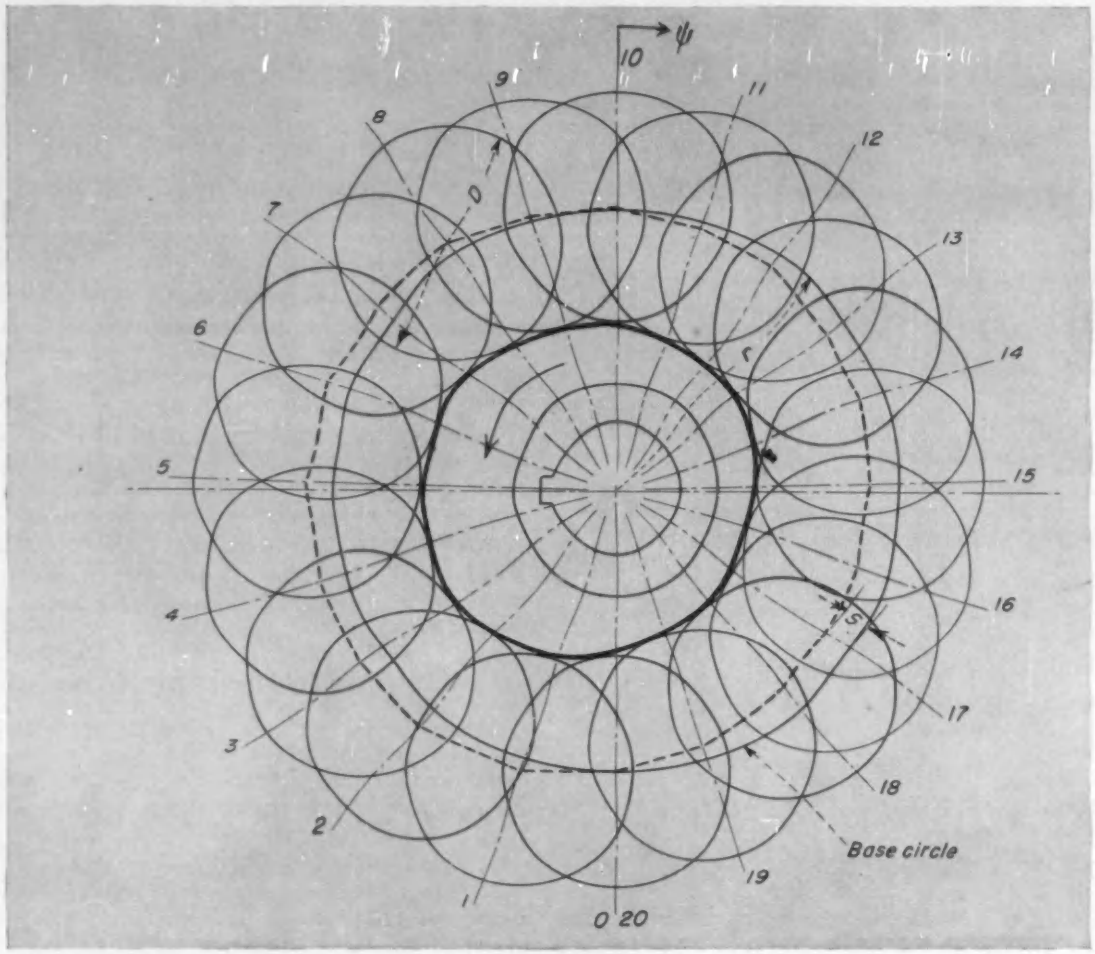


Fig. 5—Cam layout for an equalizer which eliminates pulsations in a chain driven by sprocket with four teeth.

3. Can transmit high horsepowers.
4. Uses standard gears.
5. Can easily be changed to produce any cyclic motion.

The entire device can be considered as two gear systems: an "ordinary" drive when arm 9 is considered stationary; and a planetary drive when shaft 1 is considered stationary and arm 9 is given an oscillatory motion.

Curve *b* in Fig. 4 represents the variable velocity to be imparted to the sprocket by the equalizing mechanism so as to equalize the chain motion to a constant. If arm 9 is considered stationary, the velocity ratio between shafts are

$$i_{1-2} = \frac{\omega_1}{\omega_2} = \frac{(D_5)(D_7)}{(D_4)(D_6)} \tag{12}$$

$$i_{1-3} = \frac{\omega_1}{\omega_3} = \frac{D_5}{D_4} \tag{13}$$

$$i_{2-3} = \frac{\omega_2}{\omega_3} = \frac{D_7}{D_6} \tag{14}$$

The velocity ratio of a planetary drive is

$$i_p = \frac{\omega_a}{\omega_2'} = \frac{1}{1 - \frac{(D_4)}{(D_5)}\frac{(D_6)}{(D_7)}} \tag{15}$$

The velocity ratio between the arm and shaft 3 is

$$i_{a-3} = \frac{\omega_a}{\omega_2'} = \frac{1}{1 - \frac{D_4}{D_5}} \tag{16}$$

To maintain a constant chain velocity, V_o, the sprocket must be driven with a variable angular velocity, ω_s:

$$V_o = \omega_s R \cos\phi \tag{17}$$

From Eqs (1) and (17) it follows that

$$\omega_s = \frac{V_o}{V_x}\omega_2 \tag{18}$$

Thus, the additional variable angular velocity of shaft 2 required to equalize the chain velocity is

$$\omega'_2 = \omega_2 - \omega_2 = \frac{V_o}{V_x}\omega_2 - \omega_2 = \frac{V_o}{R\cos\phi} - \omega_2 \tag{19}$$

To produce this velocity, the variable velocity of arm 9 must be equal to

$$\omega_a = \omega'_2(i_p) = \omega_2\left(\frac{V_o}{V_x} - 1\right)(i_p) \tag{20}$$

The additional variable angular velocity imparted to the cam is

$$\omega'_3 = \frac{\omega_a}{i_{a-3}} = \frac{i_p}{i_{a-3}}(\omega_2)\left(\frac{V_o}{V_x} - 1\right) \tag{21}$$

resulting in a total variable cam velocity of

$$\omega_c = \omega_3 + \omega'_3 = \omega_2(i_{2-3}) + \omega_2\left(\frac{i_p}{i_{a-3}}\right)\left(\frac{V_o}{V_x} - 1\right) \tag{22}$$

From Eqs (19) and (20)

$$\omega_a = i_p\left(\frac{V_o}{R}\right)\left(\frac{1}{\cos\phi}\right) - i_p(\omega_2) \tag{23}$$

To obtain constant chain motion, the projection of point T on the x-axis (see Fig. 1) must move with a constant velocity V_o.

$$\sin \phi = \frac{V_o t}{R} \quad \text{and} \quad \cos \phi = \sqrt{1 - \frac{V_o^2 t^2}{R^2}} \tag{24}$$

Eqs (22) and (23) can now be expressed as functions of time.

$$\omega_e = \omega_2(i_{2-3}) - \omega_2 \left(\frac{i_p}{i_{a-3}}\right) + \frac{i_p}{i_{a-3}} \left(\frac{V_o}{R}\right) \frac{1}{\sqrt{1 - \frac{V_o^2 t^2}{R^2}}} \tag{25}$$

and

$$\omega_a = i_p \left(\frac{V_o}{R}\right) \frac{1}{\sqrt{1 - \frac{V_o^2 t^2}{R^2}}} - (i_p)(\omega_2) \tag{26}$$

The variable angular velocity of the cam can be expressed as

$$\omega_e = \frac{d\psi}{dt}$$

where ψ = the angular position of the cam from a zero reference point corresponding to a zero position of the sprocket, $\phi = 0$. Eq (25) becomes

$$d\psi = \left(\omega_2 i_{2-3} - \omega_2 \frac{i_p}{i_{a-3}}\right) dt + \frac{i_p}{i_{a-3}} \frac{V_o}{R} \frac{dt}{\sqrt{1 - \frac{V^2_o + t^2}{R}}}$$

Integrating:

$$\psi = \left(\omega_2 i_{2-3} - \omega_2 \frac{i_p}{i_{a-3}}\right) t + \frac{i_p}{i_{a-3}} \text{ arc sin} \frac{V_o t}{R} \tag{27}$$

Because of the initial conditions $\psi = 0$ when $t = 0$, the constant of integration is equal to zero and does not appear in the equation.

Similarly, ω_a can be expressed as: $\omega_a = \frac{d\theta}{dt}$ and by substitution and integration, Eq (26) becomes

$$\theta = i_p \text{ arc sin} \frac{V_o t}{R} - i_p \omega_2 t \tag{28}$$

Because angle θ is small, it is assumed that the length of the arc is equal to its chord, therefore the displacement S of the cam axis (shaft 3) can be expressed as $S = \theta$ b and introduced into Eq (28).

$$S = \left[i_p \text{ arc sin} \frac{V_o t}{R} - i_p \omega_2 t\right] b \tag{29}$$

Layout of the Cam Profile

The cam can be considered fixed with the roller revolving around the cam. A base circle, as shown in Fig. 5, is drawn with an arbitrary radius r and with an arbitrary number of radial lines representing angular positions. The values of S corresponding to these positions are laid off from the base circle and circles with an arbitrary diameter D represent the roller. The heavy curve tangent to these circles is the desired cam profile.

Time, $t = 0$, corresponds to point 2, Fig. 1, and the cam makes one revolution as the sprocket moves from point 1 to 3; therefore,

$$t_{cycle} = \frac{L}{V_o} \text{ sec}$$

TABLE I—Relative angular positions of the equalizing cam, ψ, the planetary arm, θ, and the displacement of the center of rotation of the cam, S

Position No.	Time Seconds	ψ Degrees	θ Degrees	S Inches
0	−0.250	−180.000	0.000	0.000
1	−0.225	−161.179	+1.026	+0.269
2	−0.200	−139.696	+1.631	+0.427
3	−0.175	−124.459	+1.928	+0.505
4	−0.150	−106.405	+1.995	+0.522
5	−0.125	− 88.490	+1.888	+0.494
6	−0.100	− 70.679	+1.652	+0.432
7	−0.075	− 52.945	+1.318	+0.345
8	−0.050	− 35.269	+0.915	+0.240
9	−0.025	− 17.626	+0.468	+0.123
10	0.000	0.000	0.000	0.000
11	+0.025	+ 17.626	−0.468	−0.123
12	+0.050	+ 35.269	−0.915	−0.240
13	+0.075	+ 52.945	−1.318	−0.345
14	+0.100	+ 70.679	−1.652	−0.432
15	+0.125	+ 88.490	−1.888	−0.494
16	+0.150	+106.405	−1.995	−0.522
17	+0.175	+124.459	−1.928	−0.505
18	+0.200	+139.696	−1.631	−0.427
19	+0.225	+161.179	−1.026	−0.269
20	+0.250	+180.000	0.000	0.000

and the limits to be used in Eqs (27) and (29) are

$$t_1 = -\frac{L}{2V_o} \text{ sec, and } t_2 = \frac{L}{2V_o} \text{ sec}$$

Sample Calculations

Given: $V_o = 3$ ft/sec, L = 18 in., n = 4.
Desired speed reduction = 20/1
Pitch dia of gears: $D_a = 5$, $D_b = 25$, $D_c = 6$, $D_f = 24$.

$$R = \frac{1}{2 \sin 45 \text{ deg}} = 12.73 \text{ in.}$$

From Eqs (7), (8) and (11):

$$N_2 = \frac{(60)(36)}{(4)(18)} = 30 \text{ rpm}$$

$$\omega_2 = \pi \frac{(30)}{(30)} = 3.14 \text{ rad/sec}$$

$$F_{dyn} = \frac{177.7}{g} (\Sigma W)$$

and from Eqs (12), (15) and (16):

$$i_{1-2} = 20, \; i_p = 1.05 \text{ and } i_{a-3} = 1.25$$

These constants are introduced into Eqs (27) and (29):

$$\psi = 9.92t + 0.84 \text{ arc sin } (2.38t), \text{ radians} \tag{30}$$

$$S = 15[1.05 \text{ arc sin } (2.38t) - 3.30t] \text{ in.} \tag{31}$$

The time for the total cycle is

$$t_{cycle} = \frac{L}{V_o} = \frac{18}{36} = 0.5 \text{ sec}$$

Table I, contains tabulated results of Eqs (30) and (31) for consecutive points with time intervals of 0.025 sec. It has been used in Fig. 5 to construct the cam profile.

EDITOR'S NOTE—The effect of the elasticity of chain-links on cushioning shock loads has been discussed in "Elastic Elongation of Chains," *Product Engineering*, February 1952, page 176.

INTERVIEWING
Engineering Job Applicants

Too often an applicant's records and references are poor guides in the determination of his abilities. Here are suggested preplanned interviews in which the applicant's response can be interpreted and analyzed to provide a clear indication of his engineering character.

FREDERICK L. RYDER
Research Director, Simmonds Aerocessories Inc.

THE SEVERE LIMITATIONS of the average employment interview usually force the interviewer to depend to a major extent on the written record of the applicant's education, experience and accomplishments, and on evaluations furnished by the applicant's references and former employers. This method results too often in an engineering staff in which such factors as technical skill, temperament and practical judgment are hardly better distributed than they would be by a purely random selection.

Interviewing techniques which are described here, in combination with a study of the applicant's records and references, usually result in an indicative evaluation. These interviewing techniques are closely related to effective methods of continuous evaluation of the engineer after he is engaged; therefore, they have an importance over and above that relating to initial selection.

Qualities of the Competent Engineer

Qualities which make for engineering competence are: technical skill, suitable temperament and sound practical judgment.

Technical Skill. This is a combination of: encyclopedic knowledge, which consists of the understanding of fundamental physical laws and phenomena, and a knowledge of practical applications in specific fields; and the ability to apply this knowledge to the solution of practical engineering problems, or problem-solving ability.

Problem-solving involves the separation of the important and unimportant aspects of a problem; the formulation of the desired results; the simplification and idealization of the problem to render it soluble by familiar techniques, which may be either mathematical or intuitive; and modification and adaptation of the solution of the simplified problem to fit practical considerations.

Of these, the only one whose importance is universally recognized is the knowledge of specific applications, so that conventional practice in engineering personnel selection has been to place considerable emphasis on this area of knowledge. Since, however, engineering is not static but rather involves constant improvement of existing technology, the neglect of the other categories constitutes a serious omission. Fig. 1 is a simplified example of the fundamental physical laws underlying a familiar practical application.

Weakness in fundamentals and problem-solving, in which the emphasis is on concept and method respectively, may constitute a more serious limitation than lack of knowledge of specific applications, where the emphasis is on facts which to a certain extent can be looked up in handbooks or texts.

Temperament. The human personality is a conglomerate of a great number of personality traits, which vary from person to person. These traits are often largely unaffected by professional training. Thus, an individual engineer may be industrious or lazy; straightforward or scheming; diplomatic or tactless; moody or steady; excessively thorough or superficial; systematic or offhand. He may be receptive to suggestion, or he may be unable to "tune in" when being spoken to except under special circumstances, as when addressed by a supervisor. He may accept criticism gracefully, or may try to conceal his mistakes. He may judge each situation on its own merits, or he may have prejudices, as for example against new methods, or against people whose work techniques differ from his own. He may make decisions readily once the available facts are in, or he may be unable to bring things to a head. He may reach conclusions by systematic argument, or by flashes of intuition. He may be self-starting, or dependent on direction. He may be skillful or inept at explaining his ideas.

The practical effects of the engineer's "rating" in these and other similar qualities are obvious in the modern engineering organization where considerable inter-personal contact is an essential part of the work.

Practical Judgment. The engineer must make many day-to-day decisions which depend for their correctness not so much on technical skill as on general soundness and common sense. The following tasks are typical:

1. He must be able to interpret his instructions correctly, and should preferably be able to distinguish between the letter and the intent. Conversely, in giving instructions to subordinates and associates, he should be able to take account of their different levels of skill.
2. He should be able to arrange his work in logical accordance with schedules and priorities.
3. He must continually make optimum compromises, as for example in deciding how much should be invested in new equipment for a development; or how much a device should be simplified at the expense of complicating its control and operation.
4. He must decide what constitutes a satisfactory preliminary investigation of the requirements for a device before plunging into its actual development and design.

Level and Type of Position. Of course the standards of technical skill, temperament, and practical judgment against which the engineer should be judged are not fixed, but vary with the level and type of his position. With regard to technical skill, for example, in a junior engineer one would expect principally an understanding of fundamentals; in a mature non-supervisory engineer one would expect knowledge of fundamentals, specific applications, and problem-solving techniques; whereas it might suffice for a supervisory engineer to have merely an appreciation of technical skill (although in the writer's experience this is rare except in people who have technical skill themselves). In special cases, where the work is of a short-range nature, a knowledge of specific applications may be of decisive importance.

Defects of temperament may perhaps be tolerable in an engineer working on a "lone wolf" project, if balanced by superior technical skill. In supervisors, on the other hand, suitable temperament is of prime importance. Similarly, immature practical judgment may be tolerated in an engineer who is under constant direction, or where the work is of a narrowly specialized nature, but not in an administrator.

Specific Interviewing Techniques

Since the qualities of technical skill, temperament and practical judgment are to a considerable extent unrelated, a complete interview should include a separate investigation of all three. Technical skill in turn may be investigated separately in terms of knowledge of fundamentals, knowledge of specific applications, and problem-solving ability, since these are best explored by means of rather different methods. It will usually save time to investigate the qualities relating to technical skill first, since this is the area in which applicants are most likely to be deficient.

Knowledge of Fundamentals. The applicant is asked to describe some simple device or concept which should be familiar to him. For example, mechanical engineers may discuss the impact of two bodies, and in so doing should show an elementary knowledge of momentum, kinetic energy, change of kinetic energy to heat, force equilibrium, etc. Electrical engineers may discuss the transformer, showing an understanding of the laws relating flux change to voltage, and current to flux. The discussion should include sufficient detail, including suitable sketches, to show that the applicant is not merely familiar with the terminology, but has the "feel" of the pertinent physical laws. If the response is inadequate, observe whether the applicant recognizes the inadequacy, and whether he can take advantage of hints offered by the interviewer.

It is essential to keep this first part of the interview as basic as possible. Thus, in the above cases the impact would be assumed to be colinear and instanteous, and the transformer losses and magnetic leakage would be ignored. However, once the applicant has shown some competence, the discussion may be advanced in order to determine approximately his level of insight. Thus, the impact discussion may be complicated by a consideration of non-co-linearity, and of the elasticity and distributed mass of the colliding bodies; and the transformer discussion by consideration of wire resistance, eddy-current effect, hysteresis, and finite magnetic permeability of the core.

It is often revealing to question the applicant about the polarities of different parameters in a system. For example, in the following well-known flexure formula

$$M = -EI\frac{d^2y}{dx^2}$$

(where M is moment, E is elastic modulus, I is moment of inertia of the beam cross-sectional area, x is distance along the neutral axis, and y is transverse deflection), the applicant should show a set of conditions justifying the use of the minus sign, and another set where the sign should be positive. In general, those who have learned by rote instead of by understanding will not be able to do this.

Knowledge of Specific Applications. This is easy to explore by letting the applicant describe his accomplishments in some detail. It is, however, important to distinguish between a familiarity with the nomenclature and a proper understanding of the subject matter. Probe for detail where weakness of understanding is suspected.

Problem-Solving Ability. It is not practical to present the applicant with an actual engineering problem, since these are usually too complex. However, it is possible to select simplified problems which do not contain enough detail to obscure important elements, and will reveal the

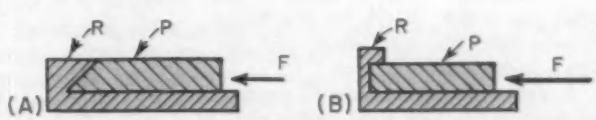


Fig. 1—Two methods of constraining the left end of plate *P* so that it does not separate from retainer *R* in which it must slide freely (normal to the paper) while subject to force *F*. A knowledge of fundamentals and problem-solving ability is required to determine that the frictional resistance in method *A* is 2.4 times that in method *B*. Space requirements may, however, affect the choice.

applicant's approximate level of skill and his method of approach in more realistic situations. Since a certain amount of encyclopedic knowledge is necesary in the solution of any problem, the selected problems should be in a field in which the applicant claims familiarity.

Inasmuch as a suitable problem will always involve a knowledge of certain fundamentals, the investigation of "knowledge of fundamentals," as described separately above, may be incorporated in the present discussion.

The response to this part of the interview is evaluated in a manner quite different from that used in conventional written examinations. An illustration is furnished in the form of a hypothetical (but representative) specific example.

In ordinary examinations the problems are usually neatly defined; in practice and in the illustration, the qualitative common-sense reasoning needed to recognize and formulate the problem is normally more difficult than the mathematical or formalistic part of the work. A further unusual feature of this method is that, even if his specific response is incorrect, the applicant will still get a high rating if his general approach is valid and strong, and if he profits by the hints of the interviewer. The latter quality is an indication of how well he learns from others.

People who do much interviewing will want to work up their own pet problems. A few examples, suitable for mechanical or electrical engineers, are suggested here:

1. A popular amusement device consists of a large pendulum which swings in a vertical plane, and which has at one end a gondola containing several passengers. What determines the acceleration experienced by the passengers as the gondola passes through its lowest point?

2. What is the distribution of pressure within a body of mercury rotating in a centrifugal device? The mercury doe not completely fill the device.

3. A resistance and capacitance are connected in series with a slowly-varying d-c voltage. How, and under what conditions, can the circuit be used to give a voltage which is proportional to the rate of change of the supply voltage?

Creativeness may be of decisive importance in problems whose solution involves the new use of basic principles. This quality cannot be determined in a short interview, but must be judged from previous specific creative contributions.

Temperament. While the applicant's temperament cannot be fully appraised in the time available in an interview, it is nevertheless advisable to conduct a brief exploration for possible serious flaws. The writer has found it indicative to describe a typical situation which involves a certain amount of psychological stress, and to question the applicant as to his behavior in the given hypothetical situation. We shall take, as an example, a difference of opinion between the applicant and his supervisor. The following are some typical reactions to this situation:

1. "If I were sure I were right, I would feel bound to convince him." This applicant apparently cannot visualize himself in error.

2. "How can we disagree if we carefully consider all the factors?" This naive approach usually leads to the feeling that difference of opinion can arise only from perversity and insincerity.

3. "He's the boss." This may indicate lack of initiative, or a recognition that it is the boss's job to make certain decisions and take the responsibility for them, or it may merely represent what the applicant thinks the interviewer wants to hear. Further exploration is neces-

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Interviewing technique for determining problem-solving ability. The problem discussed is suitable for mechanical engineers with experience or inclination in mechanics.

1. *Interviewer.* I'm going to ask you a technical question. Why is the whcel useful?

2. *Applicant.* The wheel? Why, everyone knows that.

3. *Interviewer.* Let's say everyone knows it from a layman's point of view, but we should be able to discuss it in engineering terms.

4. *Applicant.* Oh, I think I see what you mean. Well, for one thing if you lubricate the wheel you cut down friction.

5. *Interviewer.* It seems to me that lubrication can't be basic in this problem. They didn't have very good lubrication when the wheel was first invented, but it was still very useful.

6. *Applicant.* I guess you're right. (Is at a loss for further ideas.)

7. *Interviewer.* Maybe we can get to the basic advantage of the wheel by considering its first use. What do you think the inventor of the wheel used it for?

8. *Applicant.* I guess he wanted to haul something, may a slain deer, and the wheel made it easy.

9. *Interviewer.* Ah! Easier than what?

10. *Applicant.* Well, easier than just dragging it along the ground.

11. *Interviewer.* Good, If we had to define a figure of merit for the original wheel, how could we do it?

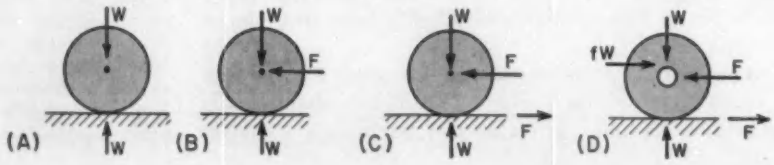
12. *Applicant.* Well, . . . how about comparing the force needed to drag the deer along the ground with the force needed to pull it on wheels . . . say in a crude wagon.

13. *Interviewer.* Excellent. The ratio of the two forces, which we can call tractive efforts, is our figure of merit. Now our job is much more straight-forward. All we have to do is show what factors in the wheel affect this ratio. What is the tractive effort when the deer is simply pulled along the ground?

14. *Applicant.* I would say fW, where f is the coefficient of friction and W is the weight of the deer.

15. *Interviewer.* O.K. What is the tractive effort when the deer is on some sort of crude wagon with wheels?

16. *Applicant.* Let's see. (Draws Fig. 2(A) and studies it.) Ah, the trac-



sary, as by discussing the extent to which a good subordinate should protest against apparently unwise acts by his supervisor.

4. "I would state my position clearly, support it by suitable argument, then shut up. From time to time I would tactfully explore whether he is prepared to change his mind, and would also check on the validity of my own opinion. If the disagreement persisted and its magnitude became intolerable, I would appeal to higher management or think of leaving." This applicant is frank and realistic, and shows a strong but restrained approach combined with the realization that he may conceivably be in error. If his response represents his normal behavior, his temperament is excellent.

Practical Judgment. If the investigation of technical skill (above) includes a significant amount of commonsense reasoning, this part of the interview may be omitted. If not, the applicant may be asked to evaluate some situation which involves sound but nontechnical reasoning. The following questions may serve as examples:

1. Is it safer for a pedestrian to cross a street in the middle of the block than at the corner?

2. What factors are involved in deciding on the amount of life insurance to carry?

The first of these will be discussed in some detail. If the applicant immediately says, "Well, of course, it's safer to cross at the corner," he is not a systematic and analytical thinker. If he cannot show any advantages for crossing in the middle of the block, he is a weak thinker. If he insists on a detailed consideration of special cases such as multiple intersections, he is an undisciplined thinker. If he reasons thus: at the corner the driver is more alert than in the middle of the block; the traffic pattern is more confusing to the pedestrian at the corner because of turns; hence crossing in the middle of the block may be safer (although perhaps illegal) for an alert pedestrian, but crossing at the corner is safer for others, especially children and older people; then he is probably analytical and independent in his thinking.

Qualifications of the Interviewer

The type of interview just described places a much greater burden on the interviewer than conventional methods of personnel evaluation. Often the requirements of technical skill, practical judgment and sympathy can be met by pooling the resources of several interviewers. Obviously, unless qualified interviewers are available, the full advantages of the method will not be realized.

Conclusions

Conventional methods of personnel evaluation can be supplemented by use of specific techniques for on-the-spot examination of applicants in the areas of technical skill, temperament, and practical judgment. However, the method places a far greater burden on the interviewer than conventional methods.

As compared with written tests (including those of a psychological nature), the method has the advantage of extreme flexibility; in fact it is guided to a large extent by the responses of the applicant.

The method also has application in the continuous evaluation of engineering personnel after they are engaged. Modern engineering is a highly cooperative effort, so that individual contributions are often hard to judge; as a result, the evaluation of many engineers is made on the basis of occasional interviews with their supervisors, in which the discussion often follows the lines sketched out here, except that it is concerned with the work in hand.

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tive effort is applied through the hub. (Adds force F as in Fig. 2(B.) Now all we have to do is evaluate *F*. Hm-m. I don't seem to have a balancing force for *F*. Oh! It's supplied by the ground. (Adds ground force *F* as in Fig. 2(*C.*) (Thinks.) I can't seem to get a value for *F*.

17. *Interviewer.* The trouble is you have made an assumption in your sketch without realizing it.

18. *Applicant.* Assumption? (Is at a loss.) How do you mean?

19. *Interviewer.* You've shown the hub as a point.

20. *Applicant.* Is that important? (Changes center point to a small circle, and is struck by a thought.) Wait! Let me try to show the friction force at the axle. (Changes sketch to Fig. 2(*D.*) Now what?

21. *Interviewer.* How about considering the summation of moments acting on the wheel?

22. *Applicant.* (Somewhat excited.) Ah, of course! I can see just by looking at it that *F* equals fW times the ratio of the two diameters.

23. *Interviewer.* So what is the figure of merit of the wheel?

24. *Applicant.* Why, simply the ratio of the two diameters.

25. *Interviewer.* It's just as simple as that. Of course we've ignored secondary effects, like the axle friction force associated with *F*, and we've assumed that the coefficient of friction at the hub is the same as between the slain deer and the ground. But our simple result really tells most of the story.

26. *Applicant.* I can't see why I had that much trouble with it.

The analysis of this dialogue is as follows. Statement 4 shows a lack of appreciation of the differences between the basic and the secondary aspects of the problem, and probably indicates a tendency to too superficial analysis. Response 6 certainly shows that the applicant is not an experienced problem-solver, for he cannot even suggest a method of approach. Responses 8 and 10 show some appreciation of practicality. Response 12 shows the beginning of a valid technical approach to the problem.

In statement 13 the interviewer endeavors to formalize (and thus simplify) the problem, since the applicant does not seem high-powered enough to do this on his own. Responses 14 and 16 show a knowledge of certain fundamentals, and the latter response contains some good analysis (which is, of course, not entirely independent, since the applicant is undoubtedly trying to relate the problem to his work in school). Statements 17, 18 and 19 point up a type of flaw which often forms an important obstacle in practical analysis. Even with this corrected, the applicant cannot evaluate *F*, but needs the help of statement 21.

Tentative conclusions: the applicant is a rather poor problem-solver but has some knowledge of fundamentals and some sense of practicality. Hence he is not suited to a position involving new and challenging problems, but may be acceptable if the work is relatively straightforward.

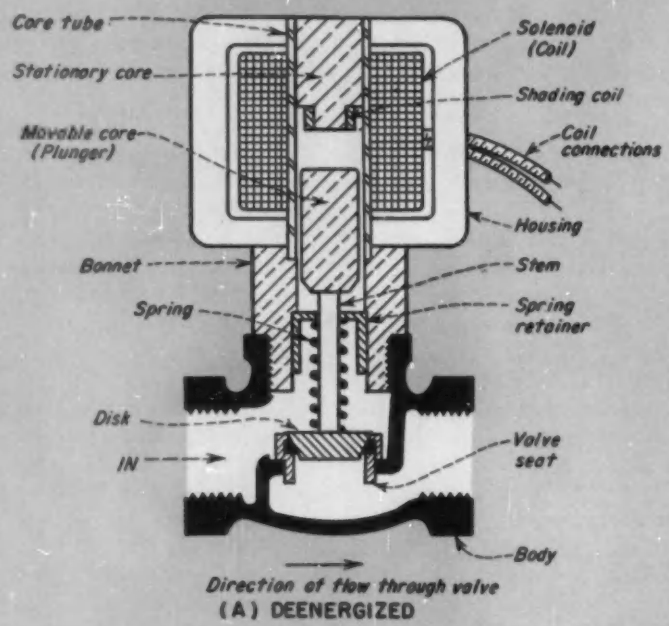
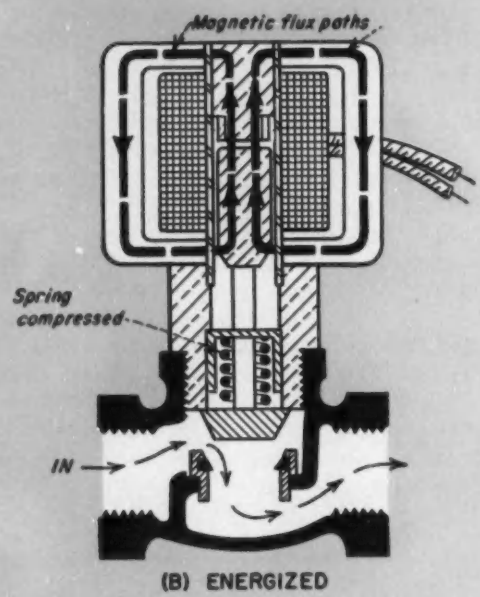


Fig. 1—Basic solenoid valve for combination of moderate pressure and flow. Left, solenoid is de-energized and spring holds valve in closed position. When the solenoid is energized, right, the plunger is drawn up and the valve disk is lifted, opening the port. For higher pressures, pilot operated or needle valves are required.



SOLENOID VALVES

for Fluid Directional Control

For control of low or high volume and low or high pressure fluid flow.
For control systems employing either manual or electrical pilot devices.
For sequential, fail-safe or combined functions.

FRANK E. REEVES, Automatic Switch Company

BOTH MANUAL AND DIRECT MECHANICAL CONTROL of valves carrying gases or liquids impose limitations on the use of such valves for automatic control. Manual control is often too slow, while mechanical control may be limited to relatively small actuating distances and simple mechanical relationships. If the valve is remote or in an awkward position relative to the source of the mechanical actuation, the design of the actuator might be involved and unwieldy, and in some cases impossible.

Solenoid-controlled valves are electrically energized and normally operate instantaneously. Because they need only wire connections to the control point no particular physical relationship between the control point and the valve position need be considered. Also, complex control sequences or combined functions can be obtained by interconnecting the valves with proper manual or automatic pilot control devices, such as push-buttons, interlocks, or timers.

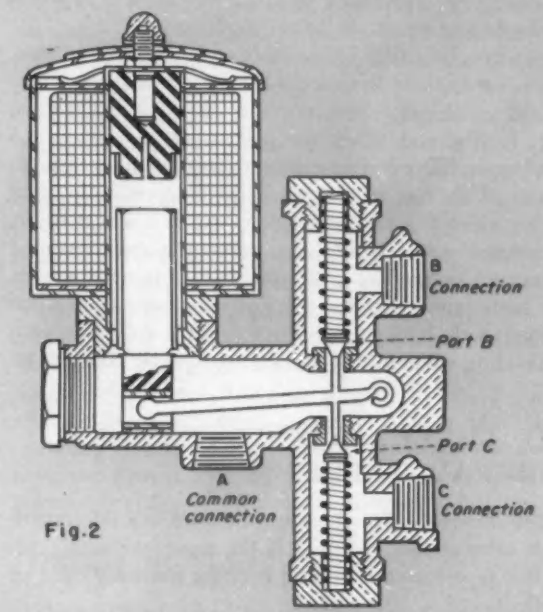
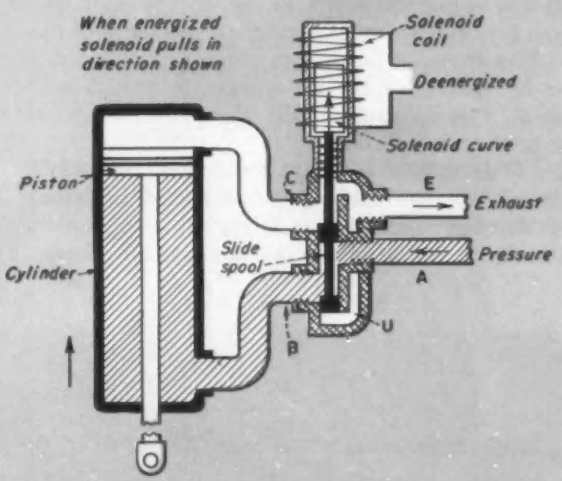


Fig.2

Flow in Three-Way Solenoid Valves

SOLENOID	PRESSURE APPLIED AT			
	A	B	C	B and C
DEENERGIZED	A→C	A→C	A→C	A→C
ENERGIZED	A→B	A→B	A→B	A→B

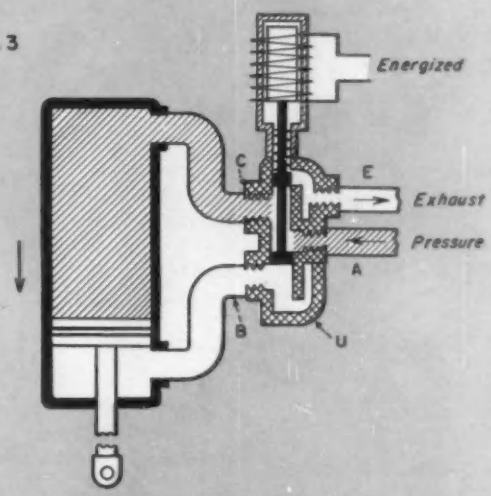
Fig. 2—Flow paths through a three-way solenoid valve showing the common pipe connection at *A* and controlled ports *B* and *C*. With solenoid de-energized *C* is open; when solenoid is energized *B* is open.



SOLENOID DEENERGIZED

Pressure from A is applied through B, against bottom of piston. Top of cylinder exhausts through C and E

Fig.3



SOLENOID ENERGIZED

Pressure from A is applied through C to top of piston. Bottom exhausts through B and E

Fig. 3—Typical application of a four-way solenoid valve, arranged here to control a double-acting cylinder.

Solenoid valves are obtainable in numerous types, sizes, and operating functions. There are valves suitable for control of low or high pressures and low or high rates of flow, for air, gases, water, and other kinds of fluids. In addition, valves with various electromechanical latching arrangements provide numerous combinations of fail-safe for protection of equipment and operating personnel against control-circuit malfunctions.

Solenoid valves are a combination of two basic functional units—a solenoid with its plunger, and a valve. The valves are opened or closed by movement of the magnetic plunger or core which is drawn into the solenoid when the coil is energized. The coil of the valve is usually encased in a protective cast or pressed-steel housing, which usually also acts as part of the magnetic circuit, and as a junction box for the electrical wiring. General purpose (NEMA Type I), waterproof or explosion-proof housings are available in most industrial types.

Both ac and dc are used to energize solenoid valves, but the construction required for each type of excitation differs

slightly. Types for ac have a shading coil in the stationary core to prevent excessive hum and chatter when the plunger is seated. In another type of ac valve the plunger does not seat, but floats in the core tube. Quiet operation is thus obtained without the use of shading coils, but the required operating current is higher.

Operating Speeds

Solenoid valves, in general, operate at high speed, the speed of operation depending upon the construction and pressure drop across the valve. However, for direct-acting valves which operate independently of the flow, a speed of two to three cycles on 60 cps (0.03 to 0.05 sec) can be expected. In the larger internal pilot-piston-operated valves opening or closing takes from four to six cycles (0.07 to 0.10 sec) depending on the size and flow conditions.

Basic valve functions are shown in Fig. 1. When the coil of the valve is not energized (left in the illustration) the spring holds the movable core and disk against the valve seat, cutting off flow of fluid or gas through the valve. Energizing the coil (right) draws the core up into the solenoid and opens the valve.

Valves may be either normally open or normally closed. Normal, as applied to solenoid valves, indicates a de-energized condition. The normally-closed valve, shown in Fig. 1, is closed when the coil is not energized. A normally-open valve is open when no current flows through the coil. The normally-open valve is commonly used when the valve must remain open as a fail-safe measure, when electric power is off. Also when the valve solenoid is connected in parallel with some other electric device, it may be required that the valve remain open even when the power is shut off to the other device. An example is the unloading valve in a reciprocating-type air compressor.

TWO, THREE, AND FOUR-WAY VALVES

Of the standard valve openings, the two-way or straight-through valve shown in Fig. 1 is the most common type. It has two pipe connections and is either normally open or normally closed.

Three-way valves have three pipe connections and two controlled valve ports as shown in Fig. 2. The chart indicates four typical flow-control conditions possible with this valve. This type can be used to control a single-acting cylinder by connecting the air cylinder to port A with pressure at B as indicated in the chart. Port C would exhaust to the atmosphere.

Four-way valves have four pipe connections and usually one pressure source which may be connected alternately to two different connections. A common application, shown in Fig. 3, is control of a double-acting air cylinder.

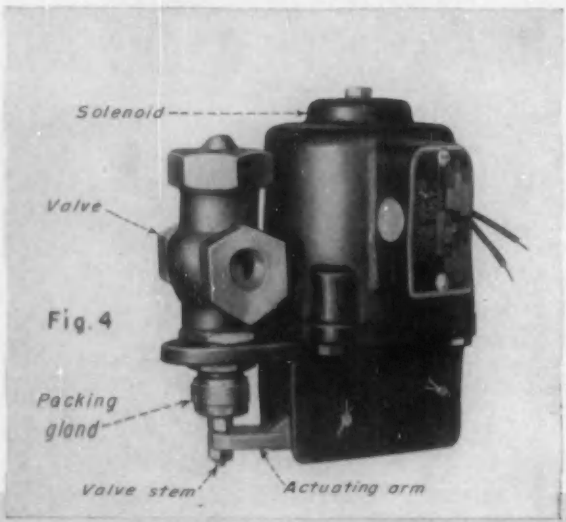


Fig. 4

Fig. 4—When fluid must be excluded from the core tube, the valve stem must be sealed with a packing. In this design the valve stem is connected to a solenoid-actuated mechanical arm which provides a mechanical advantage to overcome friction of stem packing.

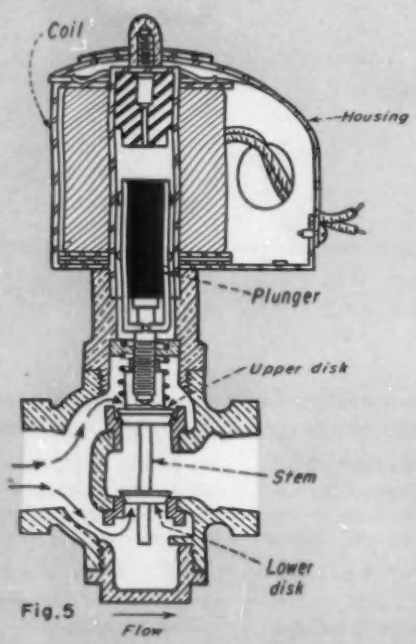


Fig. 5

Fig. 5—Semi-balanced direct-acting valve. Downward force on upper disk is greater than upward force on lower disk; the small difference in forces holds the upper disk on its seat.

Fig. 6 (A)

Fig. 6 (A) and (B)—Solenoid needle valves are particularly suited to applications requiring higher pressures and limited flow as in hydraulic control systems.

PACKLESS AND PACKED VALVES

Packless solenoid valves have no packing gland around the stem; the core tube becomes filled and the core or plunger is immersed in the fluid. The plunger, stem, disc assembly, and other internal parts of this type valve not only must be corrosion resistant to the fluid but also must not contaminate the fluid.

When handling hot fluids the coil must be capable of operating at temperatures higher than that of the fluid since the core tube will conduct heat to the coil. For higher temperature operation coils are wound with inorganic coil insulation such as glass fibre.

Packed valves are used where there is objection to the plunger being immersed or where the fluid temperature is too high for the solenoid. The solenoid and valve are separate functional units, as shown in Fig. 4. Packing around the valve stem prevents leakage but increases operating friction. To provide the required operating force the stem is actuated by the solenoid plunger through linkage providing a mechanical advantage.

DIRECT-ACTING VALVES

Direct-acting valves are usually packless and the solenoid plunger and disk are an integral assembly. This type was illustrated in Fig. 1. The force F which the solenoid must exert to open the valve is a product of the fluid pressure in psi across the valve ($P_{in} - P_{out}$) and the area A of the valve port:

$$F = (P_{in} - P_{out})\, A$$

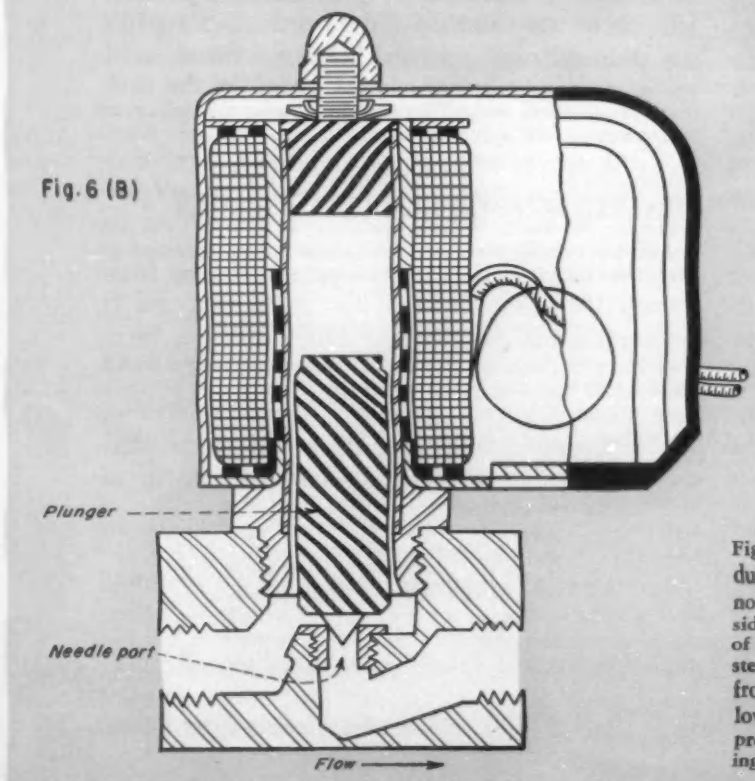
If back pressure P_{out} is zero, the force holding the valve closed is the product of inlet or line pressure and the area of the valve port. Note that the force increases as the square of port diameter. For this reason port sizes of direct-acting valves are generally small; valves with full-pipe area, in which the port or orifice area is the same as the inside of the connecting lines, are limited to lower pressures in larger sizes.

For applications requiring larger port areas at high pressures a semi-balanced construction shown in Fig. 5 can be used. In this type of valve the stem has upper and lower disks. Inlet pressure is downward on the larger top disk and upward on the smaller bottom disk. Force against the top disk is slightly greater and seats the disk when the solenoid is de-energized. The solenoid operating force required to lift the seat is therefore small.

High pressures may be handled by relatively small direct-acting solenoids using needle valves shown in Fig. 6. In these valves the port area is usually smaller than the area of the connecting lines. Flow is restricted and pressure drop through the valve is greater. Higher pressures can be used provided port openings are small, as is common in hydraulic systems.

Another approach combining higher pressures and larger port area employs pilot-operated valves. The solenoid usually actuates the pilot device, and the work of opening the main valve port is performed by other means. The most common types are: self-contained piston-actuated, diaphragm, and cylinder operated.

The self-contained piston-actuated valve, shown in Fig. 7 is more compact than types having an external pilot.



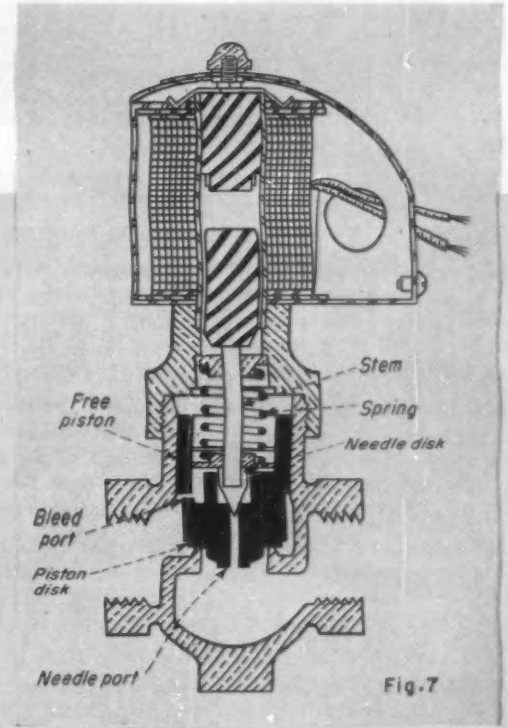


Fig. 7—Self-contained pilot-operated valve reduces the operating force required from the solenoid. Inlet pressure enters through bleed port in side of piston and exerts pressure against bottom of the disk supporting the spring on solenoid stem. When energized, plunger lifts needle disk from pilot port in center of piston. This creates lowered pressure on top of piston and increased pressure around bottom, lifting piston and opening main port.

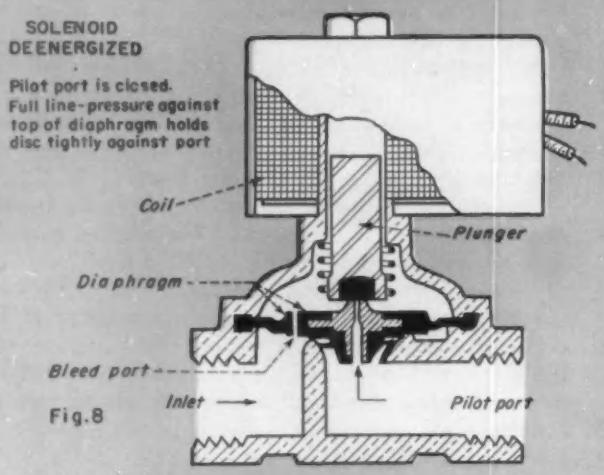


Fig.8

Fig. 8—Operation of a typical self-contained diaphragm-type pilot-operated valve. When solenoid is de-energized (as shown) pilot port is closed by seat in base of solenoid plunger. Line pressure entering bleed port holds diaphragm closed against main port. When solenoid is energized, pilot port is opened releasing pressure on top of diaphragm, and line pressure raises diaphragm and opens main port.

Fig. 9—This expansible-sleeve valve employs a three-way solenoid valve as a pilot device, making it possible to handle larger volume at higher pressure than a solenoid valve alone can control. When solenoid is energized pressure applied from the line is directed through the port connected to outside of expansible tube, pressing sleeve against central body core and closing valve. This valve is pictured at lower left-hand corner of opposite page.

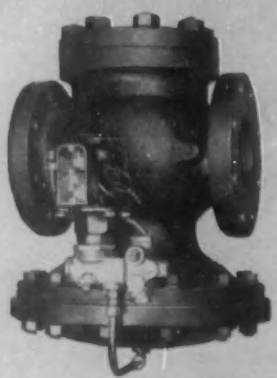
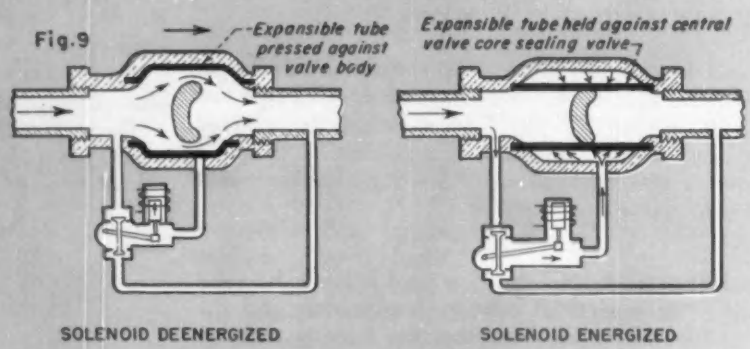


Fig.9



This valve employs a globe-valve body, is packless and has a full-pipe-area valve. The main port is closed by the seat of a free piston which moves vertically on the same axis as the solenoid plunger. When de-energized, a needle disk on the plunger stem seats on the port in the center of the piston. Inlet pressure is applied through the bleed port; fluid leaks into the upper part of the body, piston and core tube around the relatively loose fit of the piston. When the solenoid is energized, the plunger rises, the stem lifts the needle disk. Fluid then flows through the needle port into the outlet side of the main port. Since the area of the piston is larger than the port area the resultant upward force lifts the piston from its seat, opening the main port. To hold the valve open, some types require a differential force of about 5 lb, in addition to the force of the solenoid.

When the solenoid is de-energized, the pilot or needle port closes, and the line pressure plus the weight of the piston and spring force closes the valve. The pressure drop across the valve holds the piston closed and seats the disk firmly. The spring primarily holds the valve closed against a small or absent inlet pressure.

Vertical mounting is usually necessary; where a horizontal mounting is essential a stronger spring and an intermittent-duty coil may be used. Some recent designs, however, permit mounting in any position.

Packless valves of the self-contained piston-actuated type are available in sizes of $\frac{3}{8}$ to $2\frac{1}{2}$ in. and in pressures to 1500 psi in small sizes and 250 psi in larger. This type may be used for air, gases, and liquids not contaminated by rust or scale or other material carried by the fluid. Strainers or filter should be installed reasonably close to the valves on the upstream side.

DIAPHRAGM-OPERATED VALVES

Another type of internal-pilot-operated solenoid employs a resilient diaphragm. The principal of operation is essentially the same as that of the piston type, and is described in Fig. 8. The diaphragm diameter is larger than the port diameter to provide for the necessary upward force to lift the diaphragm off the main port. A pressure drop of from 3 to 5 psi is necessary and permits the use of a 10-watt solenoid to handle 5 psi to 125 psi on water and to 200 psi on air and gases. A stainless-steel spring above the diaphragm returns the plunger to normal after the solenoid coil is de-energized, permitting mounting of the valve in any position.

A second type of diaphragm-operated valve is illustrated in Fig. 11, together with a diagram showing its operation. A small three-way valve controls the position of the diaphragm which is directly connected to the valve disk.

A variety of arrangements are possible; in the typical one shown here pressure from the inlet side of the main valve operates the diaphragm, but an auxiliary pressure source may be used instead.

CYLINDER-OPERATED VALVES

Almost any valve may be controlled electrically by addition of a pneumatic or hydraulic cylinder actuated by a three or four-way solenoid as shown at top in Fig. 10. This type is suitable for handling highly-corrosive liquids and gases, or semi-solids and slurries, and is available with cast iron, bronze, or stainless steel bodies and linings of rubber, glass or a wide variety of materials. Valves sizes from ¼ to 3 in. port diameter at pressures to 150 psi are available.

EXPANSIBLE-SLEEVE VALVES

For larger sizes and high-pressure gas applications the expansible-sleeve valve shown Fig. 10 is opened or closed by the expansion or contraction of a flexible tube about a solid core in the center of the valve body. The operating cycle is explained in the diagram. This type valve may be used for liquids up to 50 psi and for air or other gases up to 300 psi in a 6-in. size. The smallest available is a 1¼ in. size.

VALVES—FOR FAIL-SAFE CONTROLS

For applications requiring fail-safe operation both safety shut-off and manual-reset valves are used. These valves are required by some insurance companies, and are also recommended in a number of safety codes. These valves essentially are solenoid types available in four classes with various mechanical latching arrangements to give the desired operating function.

Manual-reset electrically tripped valves are tripped by a solenoid. Latched-open or latched-closed construction are available: latched-open valves are opened manually and held open by a latch, and close when current is momentarily applied to the solenoid. Latched-closed valves are closed manually and held open by the latch, and open when current is momentarily applied to the solenoid.

Either type may be operated manually at any time, but will not remain in the latched position unless the solenoid is de-energized. These valves do not have no-voltage release or no-voltage protection, and thus may be used where the no-voltage feature would be undesirable as in power plants. Since they can be operated from a battery, these types are applicable when no a-c power is available.

Free-handle manual reset and safety shut-off valves are opened manually and are held open by a small, continuously energized solenoid. They cannot be opened or held open, intentionally or otherwise, unless the solenoid is energized. They close when the solenoid is de-energized, independent of the operating handle, either while the valve is being opened or is fully open.

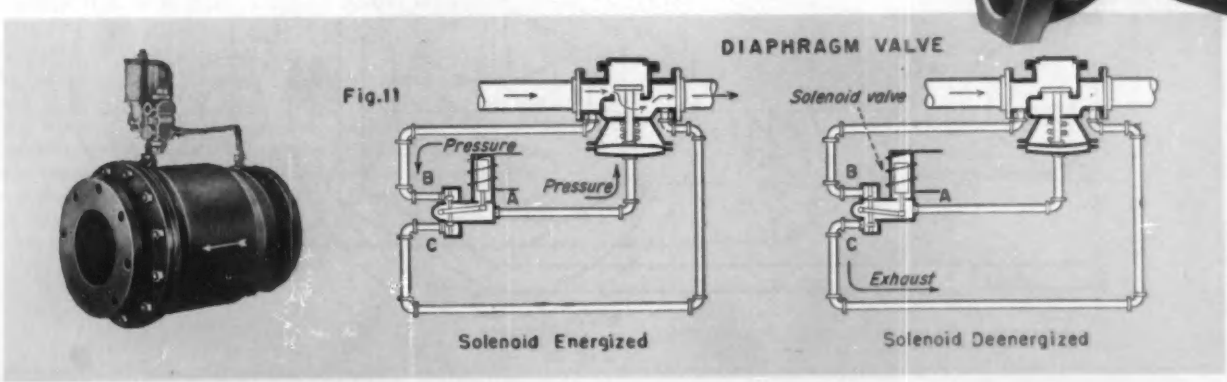
Manual reset and safety shut-off valves are opened manually and held open by a continuously energized solenoid. They close when the solenoid is de-energized and remain closed until again opened manually. They can be held open manually, but will remain open only when the solenoid is energized.

Electrically-operated manual reset and safty shut-off valves comprise an electrically-operated valve with a separately mounted relay. When current is applied through the relay by manual operation of a push-button, the valve opens. It remains open while energized and closes when current is interrupted through failure of the line voltage or functioning of control devices, remaining closed until the push-button is again actuated. The valves cannot be opened unless the current is applied, or prevented from closing when de-energized.

Fig. 10

Fig. 10—A cylinder controlled by a three-way solenoid valve, as used in this Saunders Patent valve, can operate a wide variety of valve types.

Fig. 11—A diaphragm-operated valve using a three-way solenoid pilot. When solenoid is energized line pressure from port *B* is applied through port *A* to outside of diaphragm, opening valve. When solenoid is deenergized spring pressure closes the valve. Line pressure may be replaced by an independent pressure source. This valve is pictured at lower left hand corner of illustrations on opposite page.



Pulsations in Chain Drives—

Pulsations in chain motion created by the chordal action of sprockets can be minimized or eliminated by introducing a compensating cyclic motion in the driving

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Fig. 1—The large cast-tooth non-circular gear, mounted on the chain sprocket shaft, has wavy outline in which number of waves equals number of teeth on sprocket. Pinion has a corresponding noncircular shape. Although requiring special-shaped gears, drive completely equalizes chain pulsations.

Fig. 2—This drive has two eccentrically mounted spur pinions (1 and 2). Input power is through belt pulley keyed to same shaft as pinion 1. Pinion 3 (not shown), keyed to shaft for pinion 2, drives large gear and sprocket. However, mechanism does not completely equalize chain velocity unless the pitch lines of pinions 1 and 2 are noncircular instead of eccentric.

Fig. 3—Additional sprocket 2 drives noncircular sprocket 3 through fine-pitch chain 1. This imparts pulsating velocity to shaft 6 and to long-pitch conveyor sprocket 5 through pinion 7 and gear 4. Ratio of the gear pair is made same as number of teeth of sprocket 5. Spring-

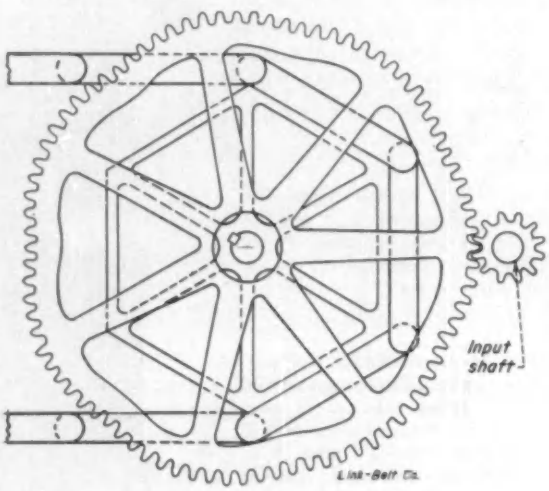

Fig. 1

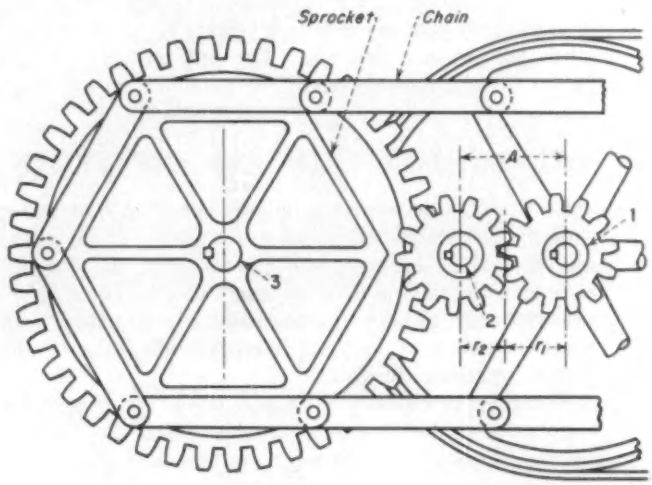

Fig. 2

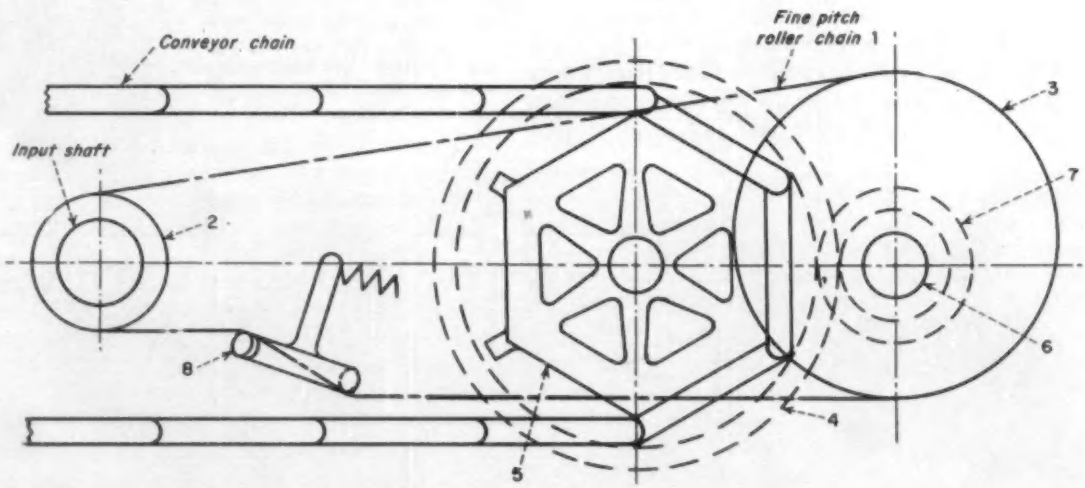

Fig. 3

Six Mechanisms for Reducing Dynamic Loads

sprocket. Here are six mechanisms for this purpose. For an analysis of chain motion see "Eliminating Pulsations in Chain Drives," page 153 in this issue.

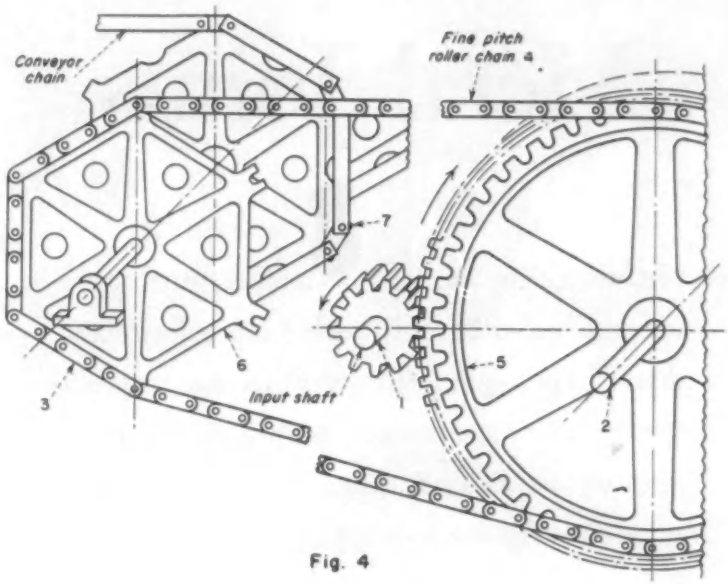

Fig. 4

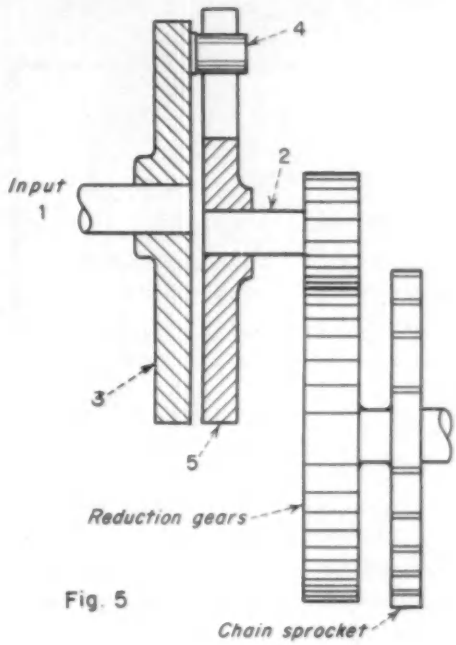

Fig. 5

actuated lever and rollers 8 take up slack. Conveyor motion is equalized but mechanism has limited power capacity because pitch of chain 1 must be kept small. Capacity can be increased by using multiple strands of fine-pitch chain.

Fig. 4—Power is transmitted from shaft 2 to sprocket 6 through chain 4, thus imparting a variable velocity to shaft 3, and through it, to the conveyor sprocket 7. Since chain 4 has small pitch and sprocket 5 is relatively large, velocity of 4 is almost constant which induces an almost constant conveyor velocity. Mechanism requires rollers to tighten slack side of chain and has limited power capacity.

Fig. 5—Variable motion to sprocket is produced by disk 3 which supports pin and roller 4, and disk 5 which has a radial slot and is eccentrically mounted on shaft 2. Ratio of rpm of shaft 2 to sprocket equals number of teeth in sprocket. Chain velocity is not completely equalized.

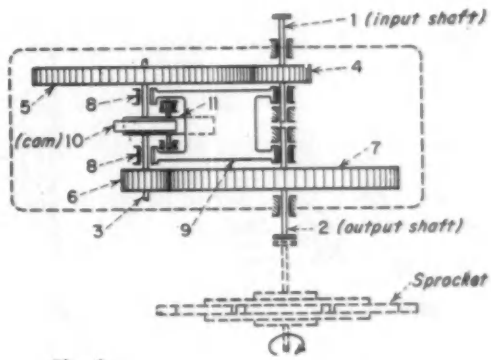

Fig. 6

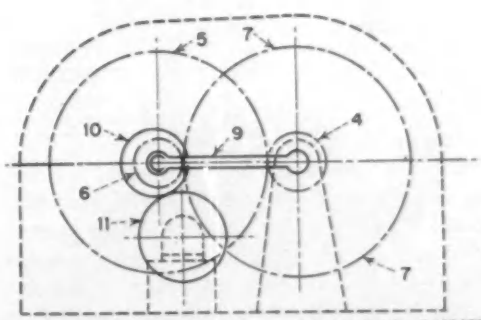

Fig. 6—Integrated "planetary gear" system (gears 4, 5, 6 and 7) is activated by cam 11 and transmits through shaft 2 a variable velocity to sprocket synchronized with chain pulsations thus completely equalizing chain velocity. Unit uses standard gears, acts simultaneously as a speed reducer, and can transmit high horsepower. A complete description of this system is included in the article "Eliminating Pulsations in Chain Drives," starting on page 153 in this issue.

Adhesive Bonded Metal Joints

Measurements of room temperature shear strength on adhesives-bonded lap joints show that rates of loading from static to impact speeds have no effect on strength. Eight different adhesives were evaluated, ranging from rigid resin-type to less rigid rubber-resin plastic compounds.

Table 1—Adhesive Types Tested

Plycozite 117-C, U.S. Plywood Corp. vinyl-phenolic; liquid, 1 part.

Plastilock 604, B. F. Goodrich Co. nitrile rubber-phenolic; unsupported film.

Plastilock 601, B. F. Goodrich Co. nitrile rubber-phenolic; unsupported film.

Epon VI, Shell Chemical Co. epoxide; liquid, 2 part.

Scotchweld AF-15, Minnesota Mining and Mfg. Co. nitrile-rubber-phenolic; unsupported film.

PA101, Bloomingdale Rubber Co. nitrile-rubber-phenolic; liquid, 2 part.

Metlbond MN3C, Narmco Inc. phenolic-nylon-neoprene rubber primer; nylon fabric tape impregnated with phenolic-nylon-neoprene rubber.

FM-47, Bloomingdale Rubber Co. vinyl-phenolic liquid, 1 part.

Four panels of each were employed. Five specimens were taken from the individual panels giving a total of 20 specimens for each adhesive.

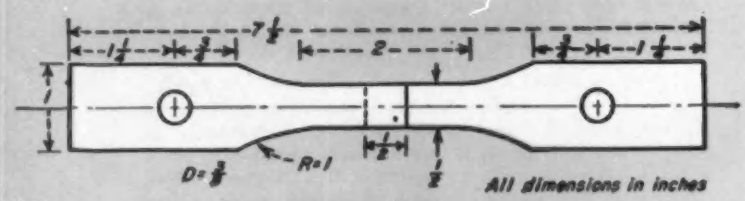

Fig. 1—Standard specimen used in the tests on metal-to-metal adhesive-bonded lap joints.

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THE USE OF ADHESIVE BONDING for joining metal structural parts has rapidly expanded as to numbers and types of applications. The adhesives used are characterized by high shear strength, good adhesion to metals, good tensile, and static and dynamic fatigue strengths. Other properties, such as peel and impact strength, application, processing, and curing characteristics, vary considerably, and choice of an adhesive depends upon what factors are most important for the particular application.

SPECIMEN STANDARDS. The mechanical properties of adhesives are usually determined for comparative reasons, and for specification and control purposes on standardized specimens. For example, the most common shear-specimen is a ½ in. overlap, 1 in. wide, lap joint specimen of 0.064 in. thick clad 24S-T3 aluminum alloy. The specimen is tested in tension in standard universal testing machines at a specified rate of loading within the normal relatively slow, testing speed range. The specimen is so designed that failure is obtained in the adhesive rather than in the metal. The adhesive failure may be entirely in adhesion to the metal, cohesive failure completely within the adhesive, or it may be a combination of both types.

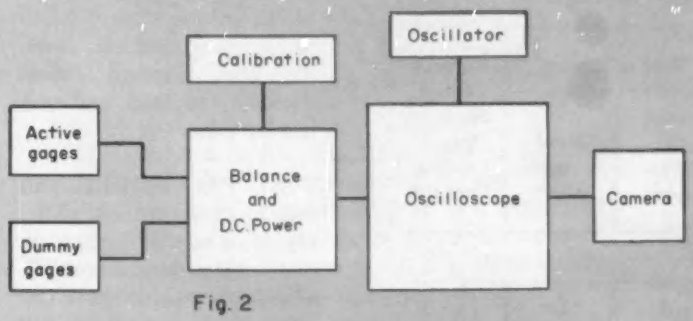
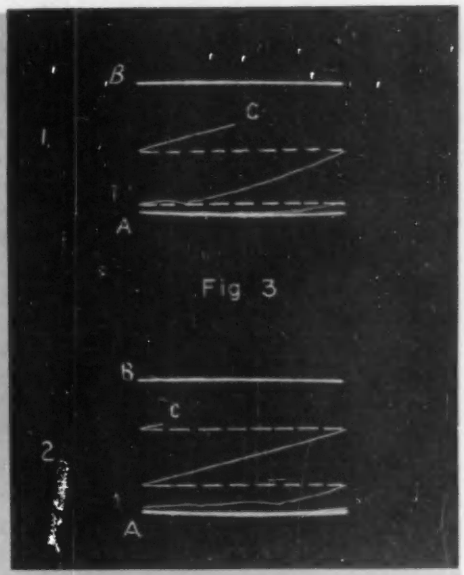


Fig. 2



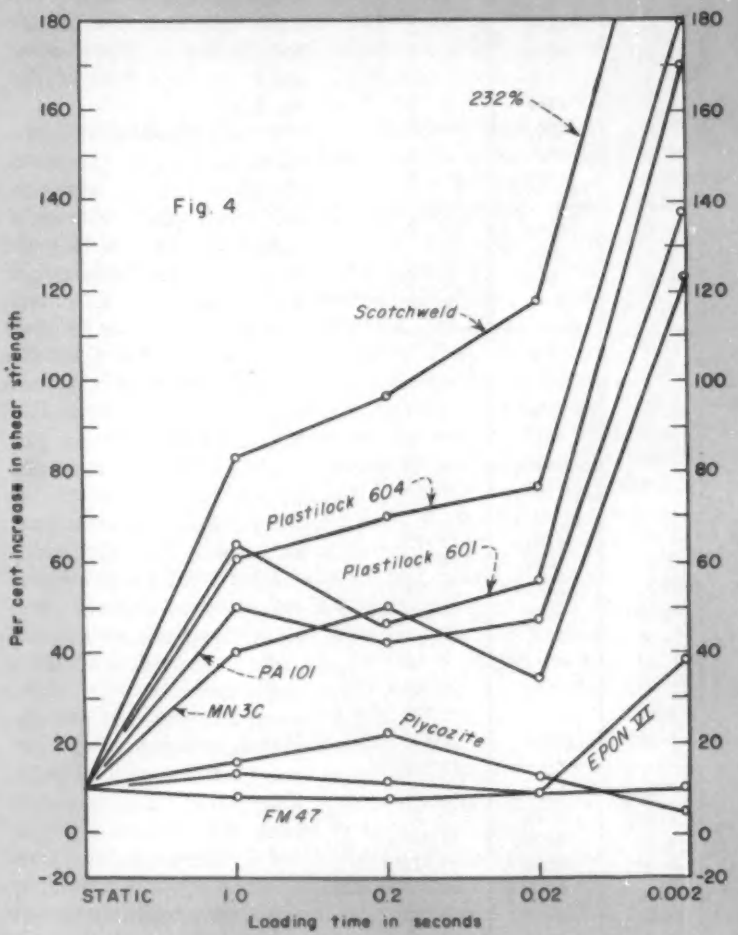


Fig. 2—Block diagram of the electrical recording system. This consists of a Wheatstone bridge utilizing SR-4 type electrical strain gages, a DC balancing unit, a cathode ray oscilloscope, an oscillator, and a recording camera.

Fig. 3—Two typical oscilloscope recordings. Line A is the zero or base point, B is a calibration line for which the distance from A is equal to a known load in pounds. The line C, which originates at A, increases its deflection as a load is applied to the specimen. The peak is where the maximum load and failure occurred. The load required to fail the specimen is then calculated by a simple ratio of the distance AB to AC.

Fig. 4—These curves show the percentage change from static to rapid loading of the shear strength of each panel as compared with the particular panel control. The curves should not be taken as being extremely accurate but they are valuable when used to compare all of the adhesives on the same basis.

NOMINAL SHEAR STRENGTH. The maximum load obtained in testing the specimen to failure, divided by the cross-sectional area of the lap, nominally ½ sq in., is defined as the nominal shear strength of the adhesive. The nominal shear strength varies with the length of the lap, and with the thickness and type of metal bonded because the stress distribution in the lap joint is not uniform with the highest stress being at the edge. Moreover, in testing these specimens, some bending is obtained. Other factors influencing nominal shear strength are the difference in adhesion to different metals and the difference in properties of the metals, such as modulus of elasticity and yield strength. Reproducible results suitable for comparative evaluation, specification, and control purposes are obtained with this standard specimen. The results can be used with caution in design, since the relation between the length of lap and shear strength can be calculated. An important precaution to take in using nominal shear strength data is the consideration of the effect of rate of loading.

The standard or nominal shear strength is determined at a relatively slow rate, requiring about 3 to 6 min to failure, depending on strength of adhesive. How do adhesive bonded joints behave at high loading rates? Is the nominal shear strength as high as at the standard slow rate? It is known that, in general, the strengths of mate-

Table II—Nominal Lap Joint Shear Strength

Adhesive Trade Name and Chemical Type	Panel No.	Static Loading Shear Strength, psi.*	Rate of Loading		Per cent Change, Static to Rapid Loading Strength
			Sec. to Max. Load	Shear Strength, psi.**	
Harder, More Rigid Types					
Plycozite 117C	1	4080	1.0	4320	+ 6
	2	4300	0.2	4820	+ 12
(Vinyl-Phenolic)	3	4320	0.02	4400	+ 2
	4	4280	0.002	4060	− 5
FM47	1	4640	1.0	4540	− 2
	2	4640	0.2	4500	− 2
(Vinyl-Phenolic)	3	3760	0.02	3720	− 1
	4	3760	0.002	3780	0
Epon VI	1	4000	1.0	4140	+ 4
	2	4200	0.2	4240	+ 1
(Epoxide)	3	3600	0.02	3560	− 1
	4	3880	0.002	5000	+ 29
Softer, Less Rigid Types					
Plastilock 604	1	2880	1.0	4360	+ 51
	2	3200	0.2	5120	+ 60
(Nitrile Rubber-Phenolic)	3	3260	0.02	5320	+ 63
	4	2900	0.002	7880	+172
Plastilock 601	1	2320	1.0	3580	+ 54
	2	3620	0.2	4920	+ 36
(Nitrile Rubber-Phenolic)	3	3660	0.02	5320	+ 46
	4	3120	0.002	8160	+162
Scotchweld AF-15	1	2520	1.0	4320	+ 71
	2	3040	0.2	5680	+ 87
(Nitrile Rubber-Phenolic)	3	2440	0.02	5080	+108
	4	2360	0.002	7840	+232
PA 101	1	3000	1.0	4200	+ 40
	2	3740	0.2	4920	+ 32
(Nitrile Rubber-Phenolic)	3	4240	0.02	5800	+ 37
	4	3880	0.002	8820	+127
Metlbond MN 3C	1	2420	1.0	3140	+ 30
	2	2420	0.2	3400	+ 40
(Phenolic-Nylon-Neoprene	3	2420	0.02	3000	+ 24
Rubber on Nylon Fabric Tape)	4	2420	0.002	5160	+113

* Average of two test results ** Average of three test results

rials increase with increased loading rate, and it is believed that this probably would apply to adhesives if they were to be tested as a material alone in uniform tensile or shear.

The stress is not uniformally distributed in a lap joint and the specimen, in effect, is one with a stress concentration related to a notched specimen in testing metals. The susceptibility to stress concentration or notch sensitivity may be increased at increased loading rates. It is possible that this effect may be greater than the effect of increase of material strength versus loading rate increase, and the net results may possibly be a decrease in the ultimate failing load and corresponding nominal shear strength of the adhesive bonded joint.

TEST PROCEDURE. An investigation was made of the effects of rate of loading on the nominal shear strength of adhesive bonded joints. Eight commercially available structural adhesives for metals were selected. These adhesives are identified in Table I.

It was anticipated that these would react differently to effects of an increasing rate of loading, because it would be expected that the less rigid types would not be as susceptible to stress concentration effects as the more rigid types. To determine possible variations of effects with the chemical type of adhesive, these four types were included: nitrile rubber-phenolic, phenolic-nylon-neoprene rubber, phenolic-vinyl, and epoxide.

Clad 24S-T3 aluminum alloy panels 6 in. wide were cleaned and adhesive bonded at an elevated temperature and pressure over a ½ in. lap joint, in accordance with the adhesive manufacturer's instructions for each adhesive. Four panels were prepared for each adhesive and five 1 in. wide specimens machined from each panel. Two specimens were tested from each panel at the standard rate of loading, or controls, and three were tested at a specific rapid rate of loading. Thus, for a given adhesive, eight specimens were tested at the standard rate and three specimens at four different rapid loading rates.

To prevent failure in the bolt holes at the grip ends, the lap joint area was reduced to ½ in. width to produce the specimen shown in Fig. 1. All tests were on specimens of this shape and size. It should be noted that the effect of width, in the range of ½ to 1 in. of these lap joints is negligible, in terms of values in psi.

The range of rates of loading investigated was as follows (standard rate of loading is termed "static"):

Static Loading: 3 to 6 min. to ultimate load (within

the range of 600 to 700 psi per min.)

Rapid Loading: 1.0 sec, 0.2 sec, 0.02 sec, 0.002 sec } Approximate time to reach ultimate load.

The last speed is in the impact range.

Load measurements for static tests were read directly from the indicator dial of the testing machine. For all other loading rates the maximum load was determined by means of strain measurements on a dynamometer placed in series with the specimen. The dynamometer consisted of aluminum alloy machined to the form of a test specimen and riveted at each end to connecting blocks. The cross section was such that the maximum strain during a test did not exceed the elastic limit of the alloy.

TEST RESULTS. The control static shear strengths of the rigid type vinyl-phenolic and epoxide adhesive bonded aluminum alloy lap joints ranged from 3600-4640 psi, while those of the less rigid synthetic rubber-phenolic types ranged from 2420-4240 psi, which is a lower range. At the highest loading rate, however, this situation is reversed. The range for the less rigid types was 5160-8820 psi, while that for the rigid types was 3780-5000 psi.

The static load column of Table II shows a separate control static strength for each of the four panels tested. The rate of loading column shows the time of loading and the corresponding shear strength for each panel. The last column shows the percentage change from the particular panel control. It should be pointed out that, considering the normal variation in results of tests of adhesive bonded joints, the control strength used could have been the average of the static strength of all four panels, since the latter results were all within the range considered typical for the respective adhesives. Therefore the last column data of Table II and the curves of Fig. 4 should not be taken as being accurate, but are of interest in comparing all of the adhesives on the same basis.

The test data for all the adhesives are plotted as shear strength versus loading rate in psi per minute in Figs. 5 and 6, and this provides some significant conclusions. Fig. 5 shows that the results in this form for all of the rigid type adhesives may be plotted together on one curve, without too much difference between the data and the curve, and this curve is essentially a horizontal line. This means that the notch sensitivity increase balances the strength increase so that there is essentially no effect of rate of loading on the nominal shear strength of the adhesive bonded lap joints.

Fig. 6 shows that the data for all of the less rigid type adhesives, except the nylon fabric supported Metlbond MN3C, fit one curve fairly well. All of these adhesives consist of films formed from solution or of unsupported tape. The Metlbond MN3C adhesive, is a supported tape utilizing nylon fabric which of course remains in the joint. The data for this adhesive fall on a lower curve of essentially the same shape as the upper curve, leading to the conclusion that a higher strength adhesive of this type might also fit the upper curve. In any case however, both curves in Fig. 5 show an increase in strength versus increased loading rate, showing that notch sensitivity does not increase as fast as strength with loading rate.

DISCUSSION OF RESULTS. The results show that at normal temperature there are no deleterious effects of increased rates of loading, from static up to the impact range, on the shear strength of these adhesive bonded half-inch lap joints, made up with 0.064 inch thick 24S-T3 clad aluminum alloy, both bonded with rigid resinous type adhesives and less rigid, rubber-resin type adhesives.

Caution must be exercised, however, in extending this conclusion to elevated or to low temperatures. It would be expected that at elevated temperatures the nominal shear strength of the joints at a given elevated temperature should increase with increasing loading rate. This is because it is considered that notch sensitivity should decrease with increasing temperature, while the rate of loading effect on the adhesive material strength itself should increase, both effects due to the plasticizing effect of higher temperatures. This does not mean to imply that absolute values of strength would not be lower due to temperature increase, but these lower values would not be expected to decrease with increased loading rate.

With respect to low temperature, it is believed that the rate of loading effects will depend on the characteristics of the particular adhesive, and in some cases, it is believed that joint strength may decrease with increased loading rate at low temperatures. This is because it is expected that notch sensitivity should increase with decreasing temperature, and also rate of loading effects on the adhesive material strength itself should decrease, due to lower plasticity and greater rigidity at low temperatures.

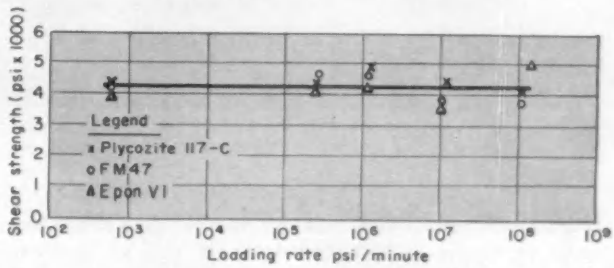


Fig. 5—The small difference in data obtained from tests on effect of rate of loading on shear strengths of rigid metal adhesives permits the plotting of all values on one curve which is a horizontal line. The notch sensitivity increase balances the strength increase so that there is practically no effect of rate of loading on the nominal shear strength of the adhesive bonded metal lap joints.

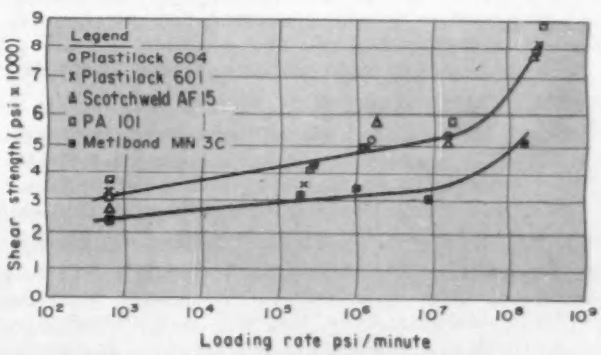
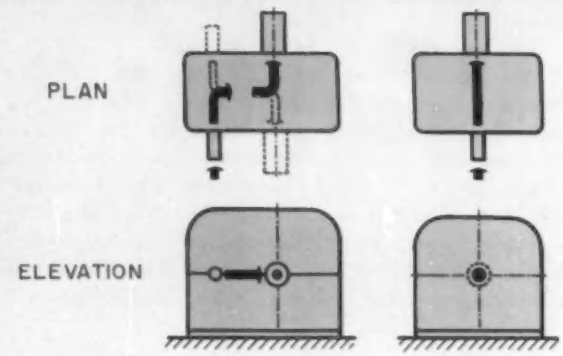


Fig. 6—The data for all but one of the less rigid metal adhesives can fit one curve. Since the lower curve has almost the same shape as the upper curve, it can be concluded that a higher strength adhesive of this type would fit the upper curve.

SPEED REDUCERS

Selection • Application

Table I - Types, Capacities



SHAFT ARRANGEMENT	Horizontal parallel offset	Horizontal parallel in-line
GEARING	Helical or spur	Helical or spur
RATIO RANGE	1.5:1 to 300:1	3:1 to 70:1
H.P. RANGE	5 to 3,000	5 to 800

Detailed procedure for choosing the type and size of standard gear reducer for a given application; how lubrication, sealing, mounting and cooling requirements influence both the selection and the application.

HENRY W. KAYSER and RICHARD J. THOMAS
The Falk Corporation

THE ONLY PURPOSE of a speed reducer is to permit both the driving and driven elements of a machine to operate at their respective optimum speeds. This is true whether the driven unit must operate at one or 10,000 rpm, whether it requires less than one or more than 1,000 hp. Also, it applies to all types of prime movers—electric motors as well as steam engines and turbines, internal combustion engines, hydraulic and pneumatic drives.

The selection of the most economical and most efficient reducer for a given application essentially reduces to a choice of (1) type, and (2) size. However, there are several factors inherent in commercial reducers that can also influence the selection. These including the following:

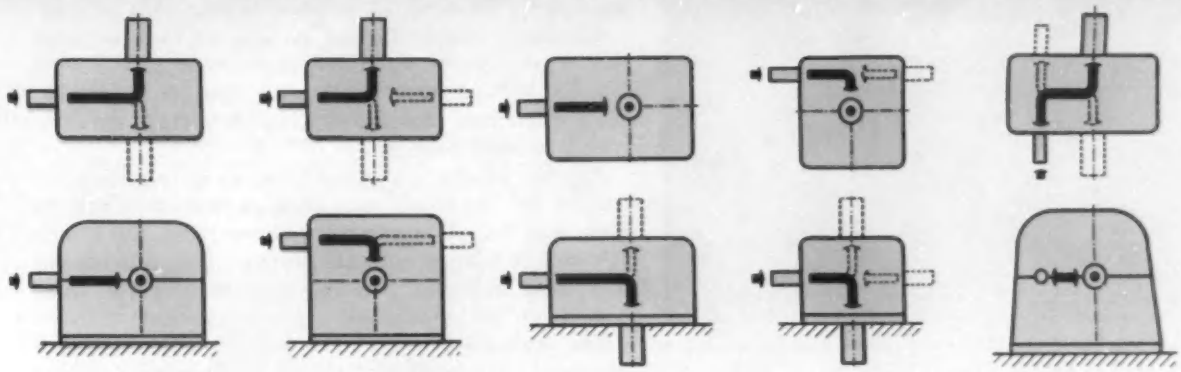
Thermal Considerations. The thermal horsepower rating of a speed reducer is the maximum horsepower that can be transmitted continuously without causing a temperature rise of more than 70 F. The housing must be capable of dissipating the heat that is generated as a result of friction in the bearings, friction at the gear mesh, and the churning of the gears dipping in the oil. In a helical or bevel gear reducer, the loss of power is approximately 2 per cent of the transmitted power for a single reduction, 3 per cent for double reduction and 4 per cent for triple reduction. In worm gear drives, the power loss varies with the gear ratio and detailed information should be obtained from manufacturers.

Commercial reducers are usually supplied without heat exchangers. They are, however, frequently equipped with fitted oil pans such as shown in Fig. 1, which limit the quantity of oil that comes in contact with the gears and thereby reduce the amount of churning and heat generated.

The thermal rating listed in suppliers' catalogs applies to a reducer which operates continuously. For intermittent operation where continuous running does not exceed three or four hours, this rating is increased materially.

Lubrication. The most common method of lubrication is by splash. Oil is carried at such a level that a sufficient amount will be thrown on the cover and walls of the housing to provide lubrication for the bearings. The amount of immersion of the gear depends upon its peripheral speed. Where speed is high, the immersion is kept to a minimum to prevent excessive churning; this can be accomplished by using a close fitting oil pan as mentioned previously. Where the peripheral speed is low, the immersion should be increased so that enough oil will be supplied to the bearings.

and Speed Ranges of Standard Speed Reducers



Horizontal right angle	Horizontal right angle	Vertical right angle	Vertical right angle	High speed
Bevel or bevel and helical	Worm	Bevel or bevel and helical	Worm	Helical
1.5:1 to 500:1	3:1 to 10,000:1	1.5:1 to 500:1	3:1 to 10,000:1	1.5:1 to 10:1
5 to 1,000	3 to 400	5 to 1,000	3 to 400	50 to 5,000

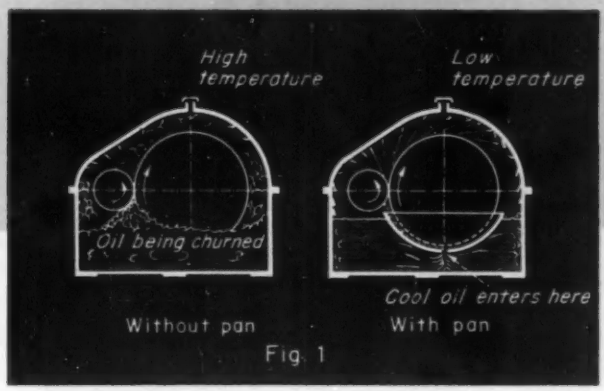


Fig. 1—Many commercial speed reducers are equipped with close-fitting pans to restrict churning of oil. Effect of operating at high speed with and without such a pan is illustrated at left.

When the speed of a reducer varies over a wide range, the user must compromise on the amount of immersion, and the proper level can be established only by tests. This is also true for units mounted vertically or on an inclined plane. Sometimes, special dams, wipers and baffles are necessary to properly lubricate the bearings.

Ambient Temperatures. Occasionally a reducer must operate at an ambient temperature exceeding 100 F. Under these conditions, the thermal rating must be larger than would be required for normal ambient temperatures. If this is not practical, the lubricating oil should be cooled artificially.

One of the dangers of operating at elevated temperatures is a rapid chemical breakdown of the oil followed by severe sludging. Experience indicates that a high grade, highly refined industrial mineral oil with a viscosity of 750-1,000 ssu at 100 F gives the best protection.

For extremely low temperatures, the oil must have a pour point less than the minimum ambient that will be encountered. On applications that must be started under full load at extremely low ambient temperatures, it may be necessary to heat the oil before starting to prevent overloading the prime mover. This can be done by mounting a thermostatically controlled electric immersion heater in the oil sump.

Sealing. In atmospheres that are heavily laden with dust, moisture or chemical fumes, good shaft seals are essential. Most manufacturers include dustproof seals, but where contamination conditions are severe, special designs are recommended. Dust, if it is abrasive, will ruin bearings in a short time, particularly the anti-friction types. A chemical atmosphere will attack the polished surfaces of ball or roller bearings or it may combine with the lubricating oil to cause sludging. Water, which can also cause rust and sludge, may accumulate from seepage past the shaft seals, or from condensation, if the unit is shut down one or more times per day.

Overhung Loads. The arrangement of machinery and the available floor space is frequently such that the take-off from the output shaft of a reducer is by means of a chain and sprocket or an additional set of gears. Usually the sprocket or pinion is mounted directly on the reducer shaft which, with the supporting bearings and housing, must withstand the resulting tangential load.

The use of an outboard bearing increases the allowable

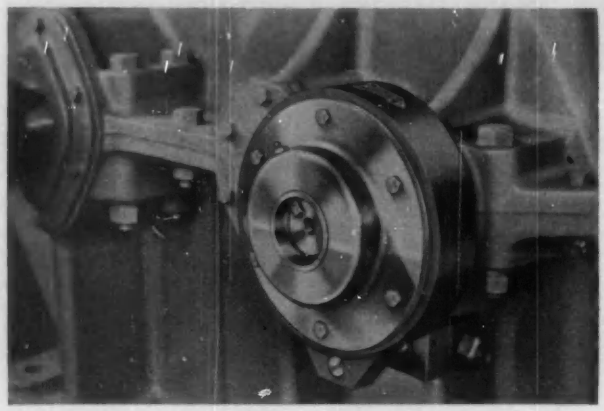


Fig. 2—Self-contained backstop anchored to reducer housing is frequently used to prevent reversal of rotation.

overhung load by 100 per cent over that where the load is cantilevered on the reducer shaft. This arrangement does have definite limitations in that it involves the use of a three-bearing mounting, but such a mounting can be acceptable if proper alignment is maintained and if the foundations are rigid. A better method is to use a flexible coupling and a jackshaft. The flexible coupling takes care of any misalignment that might occur, and in addition, dampens shock loads.

Occasionally there is a need for a belt drive at the high speed end of the reduced because of available floor space or the need for a variable output speed. Most speed reducer shafts and bearings have sufficient capacity to withstand the additional load resulting from the belt drive. However, if the allowable load is less than that required for the drive, an outboard bearing must be used.

Mounting. Standard speed reducers are so constructed that repairs can be made and replacement parts can be installed without removing the unit from its foundation. It is, therefore, common practice to embed the base permanently in concrete.

Another popular arrangement consists of mounting the reducer and the motor on a common bedplate which, in turn, may be set in concrete. Occasionally, the bed is extended to take an outboard bearing. This gives reasonably good assurance that the alignment of the three bearings on the output shaft will be maintained.

On applications where the reducer is mounted on structural steel members, they must be designed to take not only the weight of the unit but the torque reaction as well. An inadequate supporting structure may result in severe vibration.

Auxiliaries. A gear reducer is never equipped with a large number of auxiliaries, but a few are available. The backstop is probably the most popular of these and consists of a device which prevents reversal of rotation. This is usually mounted on the unused end of a shaft as illustrated in Fig. 2. Another is an overload protection device for either the prime mover, or driven equipment, or both. This is usually accomplished by using a coupling that limits the torque that can be transmitted, disconnecting the load at a predetermined value. The release mechanism may be a shear pin, a slip clutch, or a cam which effects a mechanical disengagement. These devices can also be designed to cut off the power in the event of overload.

TYPES OF REDUCERS

The types of standard speed reducers can be divided into four categories: parallel shaft; right angle; semi-high speed; and high speed. The variations within these categories and the scope of each are shown in Table I. Two other drives, the gear motor and the shaft mounted drive, are not included because the methods of selection and application are unique.

The most commonly used type is the parallel shaft design shown in Fig. 3. It is generally available in single, double and triple reduction. However, in the smaller drives, it is produced with as many as six stages. Units having concentric input and output shafts and planetary reduction gears as well as drives transmitting the power through counter shafts are also available.

Parallel shaft speed reducers are made in sizes ranging from those weighing only 20 or 30 lb and having ratings of less than one horsepower at conventional speeds to units weighing as much as 10 tons and having ratings of several thousand horsepower. The increment of rating between sizes varies from 2.0 for the smaller sizes to 1.5 for the larger sizes.

The right angle reducer has either bevel, spiral bevel, or worm gears to achieve the right angle effect. There are advantages and disadvantages to each type. Bevel gears are somewhat more efficient and can transmit more horsepower per mesh and operate at somewhat higher speeds than worm gears. The bevel gear drive, Fig. 4, has input and output shafts at the same elevation, which may or may not be desirable, but is generally limited in reduction ratio to approximately 6:1; higher ratios require additional spur or helical gears.

The worm gear design can achieve large reduction ratios with a single worm and wheel—as high as 100:1. While this promotes compactness, the lower efficiency may result in a cooling problem. Both bevel gear and worm units are available with the output shaft either horizontal or vertical, and both are generally available only with anti-friction bearings.

Although most installations are such that either a parallel shaft or a horizontal right angle reducer can be installed, space limitations or the need for multiple driven machines may dictate the use of the right angle type. It offers the further advantage of permitting two or more driven machines to be connected to the output shaft without interference from the driving motor, as shown in Fig. 5. These reducers are available in about the same range of sizes given for the parallel shaft type.

By virtue of its ability to drive a vertical shaft, the right angle vertical unit is used in machines such as lauter tubes and brew kettles in the brewing industry, agitators

Fig. 3—Parallel shaft reducer is most commonly used type. Simple split housing design makes gears and bearings readily accessible for maintenance. Bearings are lubricated from troughs at the split which are fed by splash from the gears.

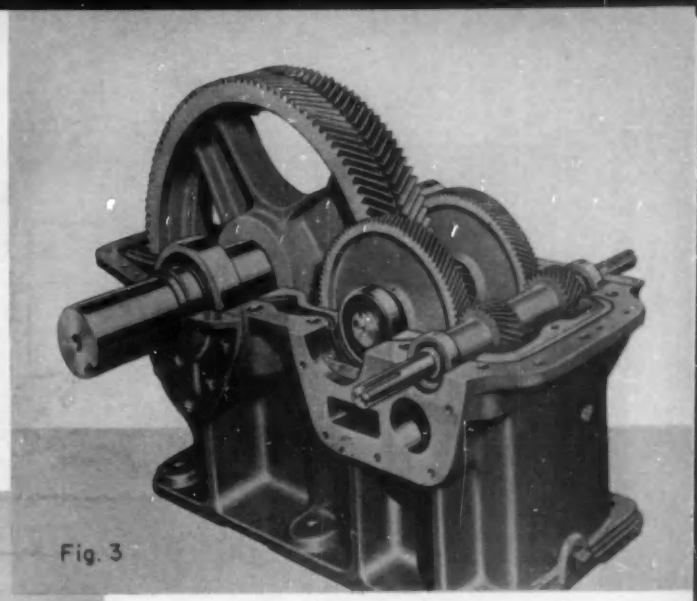


Fig. 3

Fig. 4—Right-angle drives include both bevel and worm types. Units like the bevel type shown below are available with speed ratios up to about 6:1. Worm units can have ratios of 100:1—but may introduce cooling problems because of their lower efficiency.

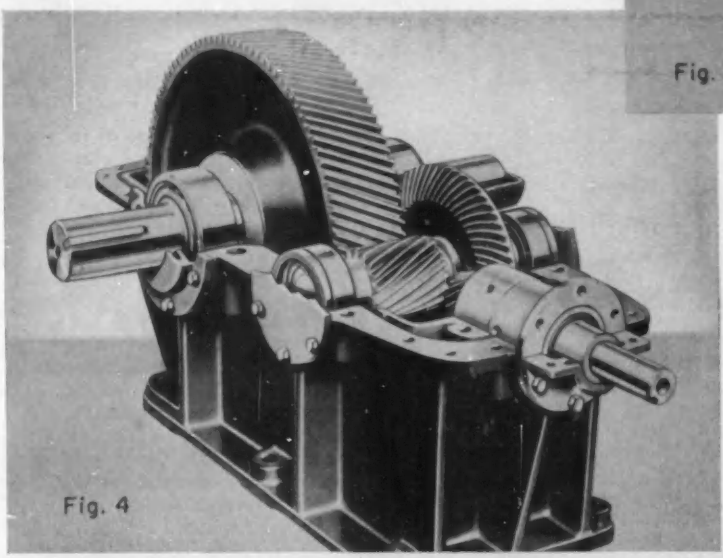


Fig. 4

Fig. 5—One of the advantages of a horizontal right-angle drive is that two machines can be driven from a single engine. Unit show here is used to drive two dock winches either singly or together with one driving motor and reducer.

Fig. 6—Right-angle vertical drive can be mounted either above or below the machine. When below the machine, as illustrated by this brewery installation, need for structural support for motor and gear unit is avoided.

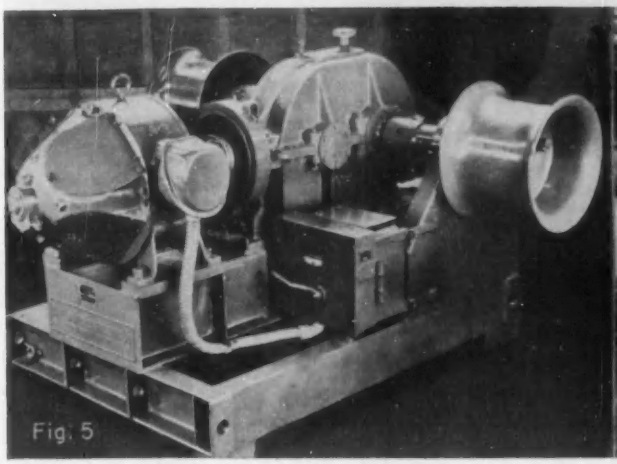


Fig. 5

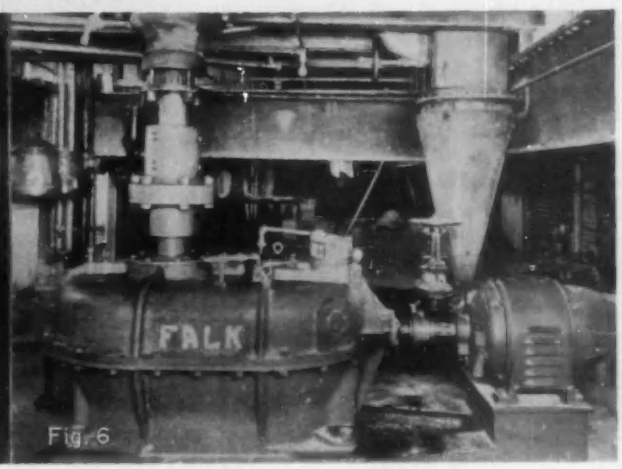


Fig. 6

and beaters in the paper and chemical industry, settling tanks in the sewage disposal field, and feeder table drives in the materials handling field. It may be located either above or below the driven machine. When below the driven machine, as in Fig. 6, the need for structural support for the motor and gear unit is avoided. However, some type of sealing is necessary at the bottom of the tank or machine.

When the speed reducer is mounted above the driven machine, packing glands or even steady bearings on the driven shaft can sometimes be avoided. However, the top of the machine may not be as accessible for loading or servicing.

In the semi-high speed classification are drives which operate at motor speeds exceeding 1,750 rpm, shaft speeds up to 3,600 rpm and gear pitch line velocities up to 4,000 ft per minute. Within these limitations there are gear units driven by small high speed motors, both a-c and variable d-c as well as those driven by small steam turbines, air turbines and the like. In this category also are gear drives used as speed increasers for centrifugal pumps or blowers powered by slower speed electric motors or internal combustion engines.

Semi-high speed units are usually made in the parallel shaft type in the larger sizes since neither bevel nor worm gears are adapted to high pitch line velocities. Al-

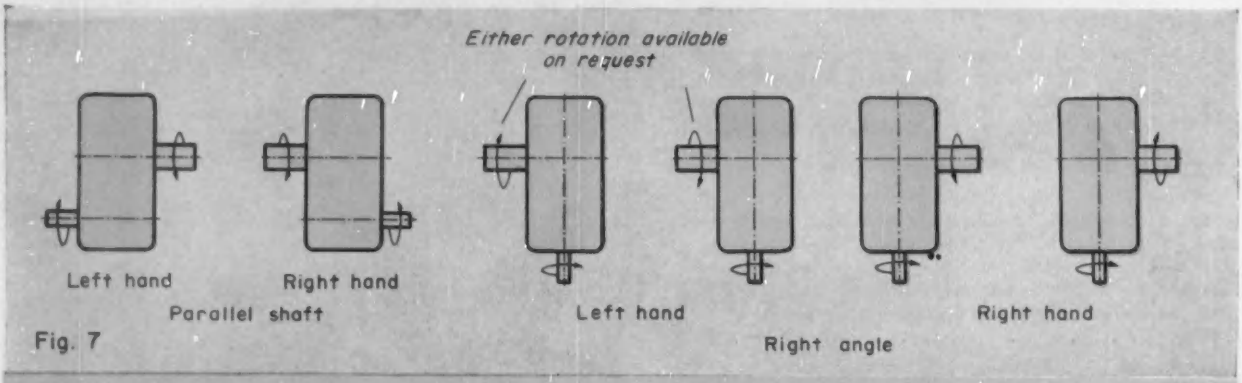


Fig. 7

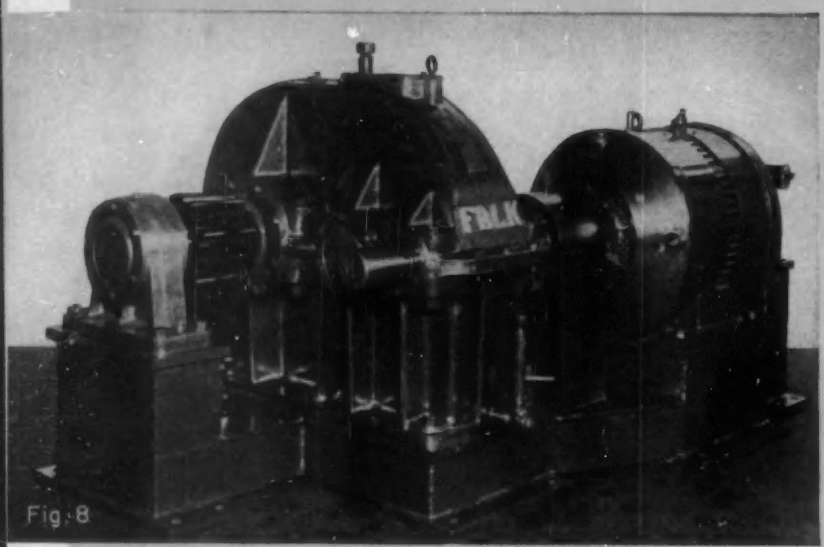


Fig. 8

Fig. 7—For the parallel shaft type of reducer, the hand is established by the extension of the high speed shaft as viewed from the high speed end of the reducer. For the horizontal, right-angle shaft reducers, the hand is established by the extension of the low speed shaft, as viewed from the high speed end of the reducer. For units with vertical low speed shafts, there is no established hand. A reducer that is made with double extended input and output shafts can be quickly changed from one hand to the other by merely interchanging the oil retainers and shaft guards. On a unit with a single extended shaft, however, it is necessary to dismantle the unit and turn the gearing end for end.

Fig. 8—Deflection of spur pinion is kept at a minimum using straddle mount with outboard bearing. Bed plate assures permanent location of bearing.

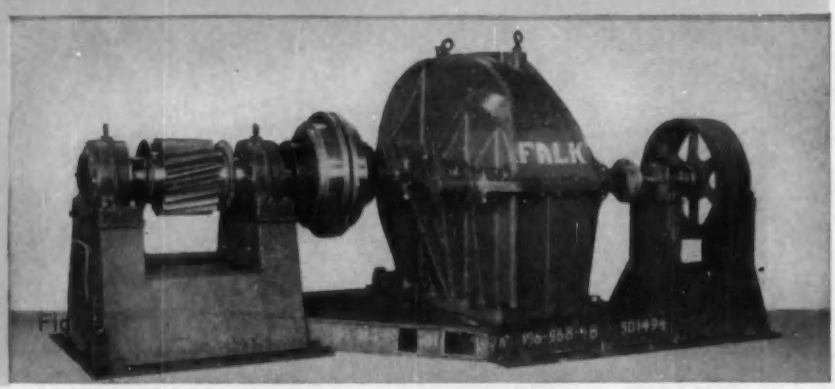


Fig. 9—Reducer mounted with jackshaft. Flexible coupling isolates outboard loads from reducer and also absorbs shock.

though most units that have been produced have ratios less than 10:1, and hence are single reduction reducers or increasers, the growing popularity of engines and reciprocating compressors operating at approximately 300 rpm has led to an increase in the number of double reduction installations.

The high speed unit covers the range of speed between 3,600 and 9,000 rpm and has gear pitch line velocities between 4,000 and 10,000 ft per minute. It is usually made only in single reduction parallel shaft design and equipped with sleeve bearings. Also, as will be discussed in a later section, its selection and application introduces several special problems.

SELECTION OF SIZE

After the type of reducer required has been determined for a specific application, the next step is to select the proper size. Gear manufacturers' catalogs contain rating tables and supplementary information needed to make a proper selection. Before attempting to make a selection, the following information should be available:

(a) Type of prime mover.
(b) Speed and horsepower rating of prime mover.
(c) Type and speed of driven machine.
(d) Actual horsepower required by driven machine.
(e) Duration of service (hours per day).

Table II - Selected AGMA Service Factors

† Electric Motor Drives

APPLICATION	10 hrs. per $ day	24 hrs. per day
AGITATORS		
Pure Liquid	1.00	1.25
Liquid and Solids	1.25	1.50
BLOWERS		
Centrifugal	1.00	1.25
Lobe	1.25	1.50
Vane	1.00	1.25
CAN FILLING MACHINES	1.00	1.25
CAR DUMPERS	1.75	
CAR PULLERS	1.25	
COMPRESSORS		
Centrifugal	1.00	1.25
Lobe	1.25	1.50
Reciprocating, Multi-Cylinder	1.25	1.50
Reciprocating, Single Cylinder	1.75	1.75
CONVEYORS—UNIFORMLY LOADED OR FED		
CONVEYORS, HEAVY DUTY—NOT UNIFORMLY FED		
Apron	1.25	1.50
Assembly	1.25	1.50
Belt	1.25	1.50
Bucket	1.25	1.50
Flight	1.25	1.50
Oven	1.25	1.50
Screw	1.25	1.50
Reciprocating	1.75	1.75
CRANES & HOISTS (See Table 2 for Dry Dock Cranes)		
Main Hoists—Med. Duty	1.25	1.50
Main Hoists—Hvy. Duty	1.75	1.75
CRANES & HOISTS (Cont'd.)		
Reversing	1.25	1.50
Skip Hoists	1.25	1.50
Travel Motion	1.25	1.50
Trolley Motion	1.25	1.50
ELEVATORS		
Bucket (Uniform Load)	1.00	1.25
Bucket (Heavy Load)	1.25	1.50
Bucket (Continuous)	1.00	1.25
Centrifugal Discharge	1.00	1.25
Gravity Discharge	1.00	1.25
FANS		
Centrifugal	1.00	1.25
Cooling Towers		
Induced Draft	1.25	1.50
Forced Draft	1.75	1.75
Induced Draft	1.25	1.50
Large (Mine, etc.)	1.25	1.50
Light (Small Diameter)	1.00	1.25
FEEDERS		
Apron	1.25	1.50
Belt	1.25	1.50
Screw	1.25	1.50
Disc Type	1.00	1.25
Reciprocating	1.75	1.75
GENERATORS (Not Welding)	1.00	1.25
HAMMER MILLS	1.75	1.75
LINE SHAFTS		
Driving Processing Equipment	1.25	1.50
Light	1.00	1.25
MACHINE TOOLS		
Punch Press & Gears—Gear Driven	1.75	1.75
Plate Planers		
Other Machine Tools—Main Drive	1.75	1.75
Auxiliary Drives (Feed Traverse, etc.)	1.25	1.50
	1.00	1.25
MILLS—ROTARY TYPE		
Ball	1.25	1.50
Dryers & Coolers	1.25	1.50
Kilns	1.25	1.50
Pebble	1.25	1.50
Rod	1.75	1.75
Tumbling Barrels	1.75	1.75
METAL MILLS		
Draw Bench Carriage & Main Drives	1.00	1.25
Forming Machines	1.75	1.75
Slitters	1.25	1.50
Small Rolling Mill Drives	1.75	1.75
Table Conveyors (Non-Reversing)	1.25	1.50
Wire Drawing & Flattening Machine	1.25	1.50
PAPER MILLS		
Agitators (Mixers)	1.25	1.50
Barking Drum	1.25	1.50
Bleacher	1.00	1.25
Beater & Pulper	1.25	1.50
Calendars		1.50
Conveyors		1.25
Couch		1.50
PAPER MILLS (Cont'd.)		
Cylinders		1.50
Dryers		1.50
Felt Stretcher		1.50
Jordans	1.75	1.75
Presses		1.25
Stock Chests		1.50
Suction Roll		1.25
Super Calendar	1.75	1.75
Winders		1.25
PRINTING PRESS	1.00	1.25
PUMPS		
Centrifugal	1.00	1.25
Rotary—Gear Type	1.00	1.25
Rotary—(Lobe-Vane)	1.00	1.25
Proportioning	1.25	1.50
Reciprocating—Single Acting—3 or more cylinders	1.25	1.50
Reciprocating—Double Acting—2 or more cylinders	1.25	1.50
RUBBER INDUSTRY		
Mixer	1.75	1.75
Rubber Calendar	1.25	1.50
Rubber Mill (2 or more)	1.25	1.50
Sheeter	1.25	1.50
STEERING GEAR	1.25	1.50
STOKERS	1.25	1.50
TEXTILE INDUSTRY		
WINDLASS	1.25	1.50

† ENGINE DRIVES — For multi-cylinder engines use the next higher service factor than shown in table above.

‡ For intermittent duty (3 hours per day) use next lower service factor than shown in above table. For occasional duty (½ hour per day) refer to factory.

(f) Direction of rotation of driving and driven machine.

(g) Hand of speed reducer, (see Fig. 7).

(h) Shaft connections—coupling, sprocket, sheave, etc.

With the above data, the selection of the correct size reducer for standard and semi-high speed service can be reduced to a step-by-step procedure:

1. *Determine the correct service factor*

AGMA Standard No. 151.01, Table II, classifies applications for various durations of service. The listed service factor multiplied by the actual horsepower transmitted is called the "equivalent required rating."

2. *Determine the required ratio*

Divide the rpm of the prime mover by the rpm of the driven machine. If the reducer is direct-connected, this is the required gear ratio. If the drive is not direct-connected, the above value is divided by the ratio of the belt drive, chain or outside gearing.

3. *Determine unit size*

Using the ratio established in Step 2, the correct size unit can be selected from the extreme left-hand column of Table III. However, this choice should also be checked for its thermal capacity by comparing the value in the second column of the table with the actual horsepower transmitted. If the actual horsepower is greater than the thermal rating, the next larger reducer must be used. In extreme cases, it may be necessary to go two sizes larger.

4. *Check the overhung load*

The magnitude of the overhung load is

$$L = \frac{126{,}000 \text{ hp}}{\text{rpm} \times \text{sprocket dia}}$$

The calculated load established by this formula must be multiplied by the following factors:

1.0 for sprocket
1.24 for pinion or gear
2.5 for flat belt

The value obtained from this calculation should be compared with the figures shown in the last column opposite the unit size that has been selected. If the calculated load is greater than the allowable, an outboard bearing such as shown in Fig. 8 or a jackshaft arrangement as shown in Fig. 9 should be used.

EXAMPLE 1

A parallel shaft reducer is required to drive a rotary gear type pump at 235 rpm. The prime mover is a 150 hp, 1,750 rpm electric motor and the application is for 24 hr per day duty. The actual requirement is 140 hp and the drive is coupling-connected at both high and low speed shafts.

Selecting the Unit

1. *Service Factor:* From Table II, the service factor is 1.25, so the equivalent required rating is 1.25 x 140 = 175 hp.

2. *Required Ratio:* 1,750/235 = 7.45:1

3. *Unit Size:* From Table III, the ratio at the top of the page which is closest to the requirement of 7.45:1 is 7.49:1. Tracing downward to find a value equal to or greater than 175 hp at 1,750 rpm motor speed, the 190 hp is chosen.

The thermal rating of this reducer is 150 hp, as shown in Column 2; this meets the requirement of 140 hp.

Table III - Horsepower Rating Table
Single Reduction Parallel Shaft Speed Reducers

Unit Size	Thermal HP	Motor RPM	STANDARD RATIOS — MAY VARY UP TO ± 2%*													OVERHUNG LOAD.	
			2.22	2.87	3.29	3.80	4.22	4.71	5.32	6.06	6.44	6.94	7.49	8.23	8.93	9.89	High Speed Shaft	Low Speed Shaft
A	47	1750	117.5	117.5	90.6	74.6	65.8	55.5	47.9	38 8	36.8	33.4	29.9	25.9	23.0	20.7	380	3500
		1170	78.5	78.5	63.8	53.4	46.9	39 6	34 1	27.7	25.9	23.6	21.3	18.4	16.1	13 8		
		870	58.5	58.5	49.9	41 6	36 4	31 1	26 4	21 4	20 1	18.4	16 7	14 4	12 7	10.9		
		720	48.4	48.4	42 1	35 3	32 0	26 1	22 4	18 2	16 7	15 5	13.8	12.1	10 6	9 2		
		580	39 0	39 0	33 9	29 3	25 7	21 6	18 5	14 9	13 8	12 7	11 5	9 8	8 6	7 5		
B	70	1750	277	212	182	153	136	113	96	81	74	64	59	51	45	40	630	5300
		1170	192	152	130	109	97	81	68	57	52	46	41	36	32	29		
		870	143	115	100	85	75	62	53	44	40	37	32	29	25	22		
		720	118	95	84	72	64	53	45	38	34	30	27	24	21	18		
		580	95	77	68	58	52	44	37	31	28	25	23	20	17	15		
C	106	1750	458	361	309	260	227	202	165	139	119	110	100	81	73	70	750	6000
		1170	306	259	223	185	160	141	116	99	91	81	73	63	58	50		
		870	228	197	168	139	122	108	93	78	71	64	58	50	45	39		
		720	188	170	145	121	105	94	77	65	60	54	48	43	38	33		
		580	152	138	120	102	90	78	64	54	50	45	40	36	31	28		
D	127	1750	458	458	453	374	335	290	245	206	181	165	147	123	110	99	750	6000
		1170	306	306	306	268	240	206	175	147	129	117	105	88	78	70		
		870	228	228	228	210	187	160	137	115	101	91	81	68	61	54		
		720	189	189	189	178	159	136	115	97	85	77	69	57	51	46		
		580	152	152	152	148	132	113	96	80	70	64	57	47	42	38		
E	150	1750	....	665	575	476	417	377	322	263	232	215	190	155	140	131	1000	9500
		1170	597	480	415	342	298	264	218	190	166	153	134	117	104	92		
		870	444	377	322	262	228	207	166	144	127	116	105	91	81	71		
		720	368	328	280	228	200	180	146	125	110	99	88	76	68	60		
		580	297	264	229	187	163	148	121	103	91	82	74	64	58	51		
F	182	1750	....	....	785	656	575	493	417	360	330	290	255	218	197	180	1250	12800
		1170	870	673	561	481	418	366	296	254	233	205	178	152	140	126		
		870	685	529	448	372	321	280	227	198	181	160	143	129	113	98		
		720	575	449	379	316	272	238	196	168	156	137	123	107	96	83		
		580	463	374	316	263	227	199	164	140	129	116	104	90	81	69		
		390	312	269	229	191	164	143	118	101	90	83	74	65	56	48		
G	230	1750	....	....	....	1030	887	781	669	542	506	447	390	345	300	265	1500	18000
		1170	1340	1018	889	749	640	541	484	386	357	318	275	251	210	190		
		870	1123	816	705	588	502	420	370	296	276	240	215	195	168	150		
		720	932	703	604	499	423	355	316	252	237	207	184	165	144	128		
		580	749	570	493	412	353	295	263	213	196	175	155	136	121	107		
		390	504	420	359	299	255	214	189	153	141	122	111	96	85	75		
H	288	1750	....	....	....	....	....	....	990	854	715	655	596	539	471	435	368	1750	24000
		1170	....	1324	1140	960	840	730	615	515	471	414	368	322	288	253		
		870	1392	1049	902	755	661	570	481	401	365	332	293	253	230	199		
		720	1152	904	774	648	566	488	413	342	312	276	247	213	191	181		
		580	930	753	648	541	474	409	344	284	259	235	222	199	173	151		
		390	650	529	465	384	338	302	254	214	197	177	158	136	121	106		
J	350	1750	....	....	....	....	....	....	1290	1092	1006	898	798	693	615	522	2000	20000
		1170	....	....	1630	1363	1210	1030	882	731	665	605	540	470	420	366		
		870	1950	1491	1289	1085	958	816	700	575	516	464	411	352	311	269		
		720	1690	1283	1110	926	820	696	591	485	440	394	344	298	265	224		
		580	1418	1080	931	772	676	580	490	402	364	328	291	252	226	191		
		390	1023	777	669	557	491	417	357	291	264	237	212	176	158	132		
K	417	1170	....	....	....	1848	1635	1405	1188	1000	900	810	720	632	545	486	2250	29000
		870	....	2030	1720	1470	1290	1111	945	781	710	621	563	480	435	380		
		720	2300	1750	1485	1262	1105	955	803	650	600	535	466	408	368	322		
		580	1853	1478	1247	1058	924	785	661	558	495	443	393	345	311	270		
		390	1250	1245	929	785	688	590	498	411	375	330	292	259	230	201		
L	492	1170	....	....	....	....	2120	1850	1547	1289	1200	1070	966	840	748	700	2750	33000
		870	....	....	2300	1920	1700	1460	1228	1017	960	845	737	655	566	518		
		720	3150	2295	2000	1655	1461	1254	1052	864	800	710	632	552	495	449		
		580	2530	1945	1673	1400	1240	1048	867	714	667	598	535	472	425	368		
		390	1830	1412	1202	1000	883	755	628	519	485	430	379	328	309	268		
M	610	870	....	....	....	2690	2360	2080	1782	1495	1370	1230	1115	955	863	760	3250	37500
		720	....	3280	2755	2320	2040	1795	1535	1267	1162	1056	994	816	737	638		
		580	3535	2765	2330	1953	1722	1507	1283	1043	966	875	794	690	610	535		
		390	2585	2020	1700	1410	1230	1083	924	748	690	621	562	483	435	389		
		200	1490	1150	961	801	699	611	520	420	390	345	311	276	247	213		

(Note that the thermal rating need only meet the actual requirement of 140 hp). The correct selection is a size "E" reducer having a 7.49:1 ratio.

EXAMPLE 2

A parallel shaft reducer is required to drive the head shaft of a heavy duty belt conveyor for 8 hr per day and operating at 45 rpm. The drive is from a 275 hp, 870 rpm motor coupling connected to the reducer. The head shaft is chain connected to the reducer low speed shaft with the sprockets having pitch diameters of 17.5 and 52.5 in. (3.0:1 ratio).

1. *Service Factor:* Equivalent required rating is 1.25 x 275 = 344 hp.

2. *Required Ratio:* Motor speed of 870 rpm divided by 45 is 19.3. Thus the required gear ratio is 19.3/3 = 6.44:1.

3. *Unit Size:* From Table III, the size "H" reducer (365 hp at 870 rpm) is chosen. The thermal rating of this reducer is 288 hp, which is adequate for the 275 transmitted horsepower.

4. *Overhung Load:*

$$L = \frac{126{,}000 \times 275 \times 1.0}{135 \times 17.5} = 14{,}700 \text{ lb}$$

Referring to the last column of Table III, the allowable overhung load for the size "H" reducer is 24,000 lb, so no outboard bearing is required.

HIGH SPEED REDUCERS

Several characteristics typical of high speed units are not found in conventional installations. First, the high operating speeds dictate the use of sleeve type bearings. Although anti-friction bearings are not prohibited, the speeds encountered are generally higher than those which can be accommodated without going to a precision type. Also, it is usually necessary or at least desirable to provide pressure lubrication to the bearings. This can be done with a separately mounted electric motor driven pump or by means of a pump mounted on and driven by the gear unit. This latter pump can be directly connected to one of the reducer shafts or it can be driven by a small set of gears, as shown in Fig. 10. It is not advisable to permit the gear to dip freely in the lube oil. However, the gear mesh can be lubricated by surrounding the part of the gear below the level of the oil with a close fitting pan, Fig. 1, having carefully proportioned orifices which permit a limited quantity of oil to enter the pan and be picked up by the gear. The more common method of lubrication is by completely excluding the oil in the sump from the gear, and spraying the mesh with oil from the pumping system.

It is also typical of high speed units to require artificial cooling to absorb power losses. This can be achieved with an oil-to-water tube and shell type heat exchanger which is common in units having a separate pumping system. On units lubricated entirely by splash, cooling also can be effected by using splash coolers in the cover or coils in the base.

Because the pitch line velocity makes it necessary to utilize precision gearing, and carefully aligned bearings with accurately controlled clearances, it is not advisable to carry overhung loads on either the high speed or low speed shafts. Both should be connected to the driving and driven machines by flexible couplings. These will accommodate small misalignments inherent in the installation without imposing extraneous loads on the shafts.

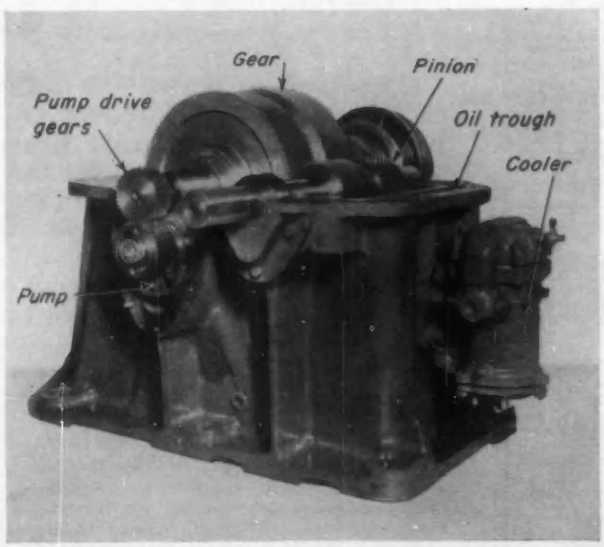


Fig. 10—High speed reducer. Housing forms a large oil reservoir, permitting the use of a self-contained pressure lubricating system including a gear driven pump and oil cooler.

Typical applications of high speed units used as speed reducers include those having a turbine (steam, air or gas) or high speed motor driving a slow speed machine such as a gear pump, reciprocating pump, reciprocating compressor, sugar mill, paper machine, fan, etc. Typical of those used as speed increasers are units driven by comparatively slow speed prime movers such as internal combustion engines and slow speed electric motors. These drive high speed machines such as centrifugal compressors, centrifugal pumps, refrigeration compressors, etc.

When the high speed machine connected to the gear drive requires both pressure lubrication and cooling, it is usually possible to design a combined lubrication system which will accommodate both the gear unit and the machine from a common lube oil supply. Such a system generally includes a lube oil sump, a motor driven pump to pressurize the system on starting, a direct-connected pump for continuous operation, a heat exchanger of sufficient capacity to accommodate both machines, and a filter, as well as the necessary controls such as pressure regulating valves, thermostatic controls, bearing temperature relays, pressure gages, thermometers and alarm devices.

Couplings. In many cases where a high speed increaser unit is driven by an electric motor, it is desirable to axially position the motor rotor by means of the low speed shaft of the gear drive. This may be done by using a coupling that has limited end-float between the motor and low speed shaft, thus positioning the motor rotor by means of the low speed bearings. A rigid axial connection between the low speed shaft of a high speed unit and a machine having thrust bearings of its own should be avoided.

With internal combustion or reciprocating engines, the effect of couplings on the vibratory problems must be considered. In the event that there are natural frequencies within or near the proposed operating speed range, some modification to the system must be made to insure satisfactory operation. One such modification consists of providing couplings, either high speed, low speed, or both, having the proper torsional stiffness characteristics to tune the natural frequencies away from the operating speed range. For this purpose, there are torsionally rigid couplings such as internal-external tooth type and those using laminated disks, a rubber element in shear or a steel grid member.

A fluid coupling, or an electric or eddy current coupling may also be a possible solution to the vibration problem. These offer two further advantages in that they permit operation of one or two of the connected machines without operating all of them. Such problems occur in applications where two prime movers are coupled to a gear unit to provide an emergency power source.

Mounting. High speed units are usually permanently mounted on a rigid foundation consisting of reinforced concrete or structural steel. Occasionally, however, they are incorporated in a portable pump drive or electric generating set. In such applications, consideration must be given to the rigidity of the housing and its ability to maintain alignment of the gears, as well as the ability of the mounting structure to maintain alignment of the connected equipment.

As a rule, a standard high speed unit is required to

Table IV - High Speed Reducer Service Factors

APPLICATION	PRIME MOVER: Motor or Turbine	PRIME MOVER: Internal Combustion Engine (Multi-Cyl.)
GENERATOR (normal application)	1.0	1.5
PUMPS		
Centrifugal (general service)	1.1	1.5
Centrifugal—hot oil	1.5	...
Centrifugal—boiler feed	1.5	...
Centrifugal—pipeline	1.5	1.75
Centrifugal—water works	1.5	1.75
Centrifugal—descaling (with surge tank)	2.0	...
Dredge	2.2	2.5
Gear	1.5	1.75
Rotary—lobe type	1.7	2.0
Reciprocating—3 or more cylinders	1.7	2.0
Reciprocating—2 cylinders	2.0	2.25
FANS AND COMPRESSORS		
Sliding vane compressor	1.2	1.5
Forced—draft fan	1.3	1.5
Centrifugal compressor	1.3	1.75
Induced draft fan	1.5	1.75
Industrial blower (repeated starting and stopping cycle such as in steel mill)	1.5	1.75
Nash compressor	1.7	2.0
Reciprocating compressor—3 or more cylinders	1.7	2.0
Reciprocating compressor 2 cylinders	2.0	2.25
Lobe—type compressor	1.7	2.0
Refrigerant compressor for air conditioning service	1.0	...
MISCELLANEOUS		
paper machines—sectional drives	1.5	...
Paper Machines—line shaft	1.1	...
Belt or rope drive for reciprocating apparatus	1.3	1.5
Belt or rope drive for other than reciprocating apparatus	1.1	1.5

Table V - High-Speed Gear Units

Hp. ratings are based on 1,000 rpm of H.S. shaft

Unit Size	RATIOS: 1.15	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
1	51.0	42.3	32.6	25.6	20.6	16.9	14.1	11.9	10.2	8.70	7.70	6.73	6.02	5.37	
2	96.5	80.3	61.8	48.6	39.1	32.0	26.7	22.6	19.3	16.8	14.6	12.9	11.5	10.2	9.15
3	212	176	136	107	86.0	70.4	58.7	49.7	42.5	36.7	32.1	28.3	25.1	22.4	20.1
4	393	326	252	198	159	130	109	92.0	78.7	68.0	59.4	52.3	46.5	41.5	37.2
5	728	604	465	366	295	241	201	170	146	126	110	97.0	86.0	76.8	69.0
6	1160	961	740	583	469	384	320	271	232	200	175	154	137	122	110
7	1740	1440	1110	875	703	576	480	407	348	300	262	231	205	183	165

Table VI - Maximum Permissible Rpm

Unit Size	RATIOS: 1.15	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
1	6860	7950	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
2	5480	6380	7650	8910	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
3	4110	4775	5740	6680	7640	8590	9000	9000	9000	9000	9000	9000	9000	9000	9000
4	3430	3975	4780	5570	6370	7150	7950	8750	9000	9000	9000	9000	9000	9000	9000
5	2750	3190	3830	4400	5100	5740	6350	7000	7640	8290	8930	9000	9000	9000	9000
6		2785	3345	3890	4450	5010	5560	6120	6680	7260	7800	8350	8920	9000	9000
7			2865	3330	3815	4290	4770	5250	5725	6210	6680	7150	7640	8120	8590

operate only as a horizontal floor mount. Any requirement for a wall, ceiling, vertical or slope mount requires a custom-made unit.

Operating Sound Level. The question of operating sound level is one which has been discussed at great length without reaching a specific and universally acceptable definition or specification.

The American Gear Manufacturers Association has done considerable work in an attempt to establish standards for sound level specifications for gear units. After making many tests and observing reducers in operation under various degrees of related noise, it was decided that any specification which could be written would not be practical. In at least one instance, the user has requested that it shall be possible for two persons to conduct a normal conversation five feet from the gear unit operating at full speed and full load. Usually, however, it is satisfactory for the manufacturer to guarantee that the unit will operate at a sound level which will not cause discomfort to those in the immediate vicinity.

Selection of Size

The procedure for selecting the size of high speed reducers differs from that of standard and semi-high speed units in several aspects. These include:

(1) Service factors are given in Table IV.
(2) No cognizance is taken of duration of service.
(3) Size chart is Table V.
(4) Unit must not exceed allowable ratings in Table VI.

EXAMPLE 3

A speed increaser is required to drive a centrifugal compressor in a chemical plant at 6,000 rpm. The prime mover is 1,750 rpm, 300 hp electric motor.

Selecting the Unit

1. *Service Factor:* From Table IV, the service factor is 1.3 for a centrifugal compressor.

2. *Gear Ratio:* 6,000/1,750 = 3.43

3. *Equivalent Required Rating:* 300 x 1.3 = 390 hp

4. *Equivalent Rating* (per 1,000 rpm of the high speed shaft): 390 x (1,000/6,000) = 65. From Table V, under the column headed 3.5 which is the nominal ratio nearest that which is required, trace down until 70.4 is reached. A size 3 unit is selected.

Checking the allowable rpm in Table VI, the size 3 unit at 3.5 ratio can be operated at a pinion speed of 8,590 rpm max, hence the selection is satisfactory.

EDITOR'S NOTE—As pointed out by the author, the shaft-mounted speed reducer has not been included in this discussion because of its specialized characteristics and applications. It has, however, been discussed and described in two previous articles in *Product Engineering*. One began on page 170 of the July 1953 issue; the other on page E7 of the *Annual Handbook of Product Design for 1955*.

Data on gear motors can be obtained from manufacturers listed in the Index of Products in each issue.

BEADING TECHNIQUES

For Strengthening Sheet Metal Parts

—to minimize weight and material thickness

Design criteria and specifications for sheet, angle, tube and assembly beading in steel, aluminum, magnesium and other common materials.

BERNHARD ROGGE
Evaluation Engineer, U.S. Army Chemical Corps.

STRENGTHENING OF SHEET METAL PARTS is often accomplished by use of stiffening members, such as angles, "Z" sections, and channels to add required strength at points of high stress. Often, properly designed beading will serve just as well and at lower cost and weight. In addition to strengthening, beading minimizes problems of "oilcanning" and buckling.

Beading can be applied to curved as well as flat sheets, blending into the flat or shallow contour of the part as at *A* in Fig. 1, run continuous from edge to edge as at *B*, or be continuous within the sheet as at *C*, where the barrel shape shown is to be strengthened.

For greatest structural rigidity, the beads should be as deep as possible; thus, bend size and shape depend primarily on the degree to which the sheet metal can be formed without fracturing. The high-strength aluminum alloys are the most difficult to form, yet beading designs have been developed for these materials.

NOTE: The opinions expressed are those of the author and are not to be construed as official or reflecting the views of the United States Government.

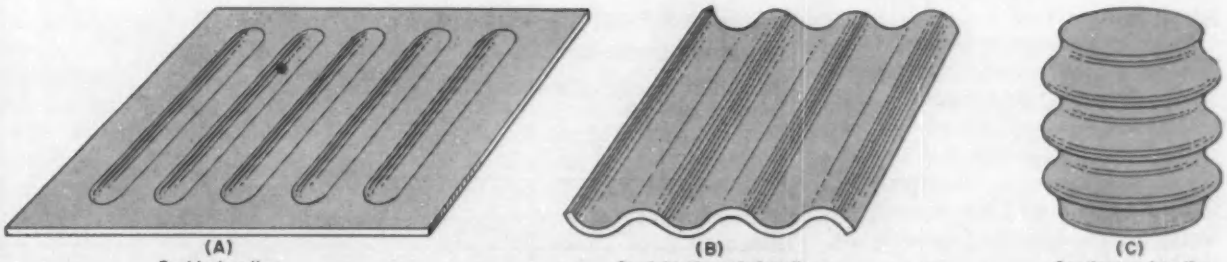


Fig. 1—Beading of thin sheet can give rigidity without adding the extra weight encountered when stiffening members, such as angles, "Z" sections and channels, are used. The most common forms of beading are "inside beading", shown at *A*, where the ends of the formed beads blend into the flat sheet; straight-through beading, as at B, most commonly used in corrugating sheet; and continuous beading, *C*, such as is used to strengthen cylindrical shapes or flat sheet around lightening holes.

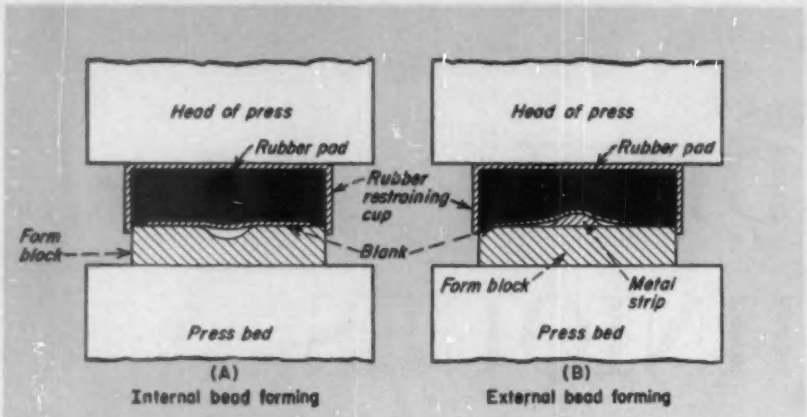


Fig. 2—With "internal bead forming", as at *A*, where a rubber pad is used in a hydraulic press, the blank is held down around the bead while the bead is stretch formed into the cavity in the die. With "external bead forming", at *B*, the blank is clamped on the crown of the bead strip with subsequent pressure forcing the metal down and away from this point; somewhat deeper beads are thus possible without metal fracture.

HOW THE PROCESS USED AFFECTS THE BEADING

Beading can be accomplished in many ways. While usually done by punch and die in a mechanical press, beading may also be produced by a form block with rubber pad in a hydraulic press (Guerin process), by drop hammers, or with beading machines.

When, as usual, beading is done as a part of the overall forming operation, its design is incorporated into the forming dies. When a separate operation, beading is done by using special tools or machines after the sheet contour is established.

Maximum depth of bead that can be formed depends not only on the elongation of the metal but also on the method of forming. For example, 24SO aluminum alloy will fracture with 12 per cent stretching when beads are rubber-formed in a hydraulic press; yet, hand hammering sometimes permits 16 per cent.

With hydraulic press forming, form blocks are usually made from pressed wood, plastic, and other materials that can be readily sawed, routed and machined, resulting in low cost tooling. All forming is done in one operation. If the bead is routed out in the form block, "internal beading" results. As the head of the press holding the rubber pad descends and contacts the metal blank, the blank is held in contact with the block as at A in Fig. 2. As pressure builds up, the metal stretches and fills the cavity of the bead form in the block. Most of the stretching occurs in the bead area, although the metal adjacent to the bead yields slightly. If the bead is near the edge of the sheet, the metal will tend to "neck-in" and flow into the cavity of the form block without stretching.

When metal bead strips are built up on the form block as at *B*, "external beading" results. The metal blank rests on top of the bead strips; and, as the head of the press holding the rubber pad descends, the highest pressure occurs on the crowns of the beads. The metal blank is locked at these points; and, as the pressure increases, the metal between the bead strips is stretched until it bottoms on the form block. Since the deformation is spread progressively over a large area, an external bead can be formed deeper than an internal one of the same curvature. This advantage is offset somewhat by the rather large edge radius which results with external beading; yet, because of the sharper contours, external beads make more effective stiffeners.

When a mechanical press is used, matched male and female dies are shaped like the bead to be formed. In operation, the male die first contacts the blank and begins to form the bead before a holding contact is established. This so stretches and distorts adjacent material to be objectionable for some parts. An improvement results by using a double-acting die and a spring-loaded pressure pad to keep the metal from wrinkling as the head is formed in the sheet.

When a drop hammer is used to form beads, a rubber pad is placed on the metal blank to soften the first initial blow, and thus prevent excessive wrinkling. On subsequent blows, the rubber blanket is removed and the final sharp impression is imparted to the metal.

Beading machines are used to roll beads into formed circular objects, such as pipes, cans, and barrels for stiffening or as stops for attachments.

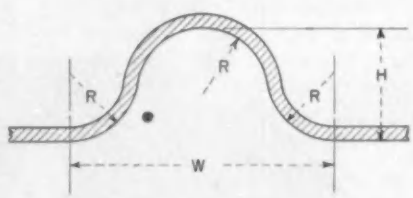
Table I—Design of Straight-Through Beads

Brake formed or rolled and uniform from end to end of sheet

Material: All; 0.010 to 0.051 in. thick

Tolerances: ± 1/32 in.

Spacing: 1 in. min, centerline to centerline of beads



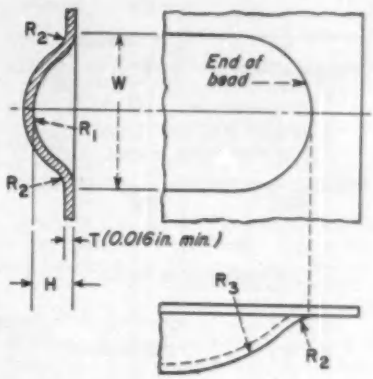
	Bead Height, H						
	3/32	1/8	5/32	3/16	7/32	1/4	5/16
Bead and corner radius, R*	0.056	0.075	0.093	0.112	0.131	0.131	0.187
Bead width, W	0.225	0.300	0.375	0.450	0.525	0.525	0.750

* Cannot be less than the minimum bend radii given in Table VII.

Table II—Design of Inside Beading

Material: All aluminum alloys, with heat treatable alloys in soft condition; all magnesium alloys (cond. "0"); and corrosion resistant steel (annealed); min gage 0.016 in., max gage as shown in table for each material.

Tolerances: ± 1/32 in. general; ± 1/16 in. for bead end location and for *H* over 0.150.



Individual Bead Design Data (Straight or curved and any length)

	Bead Height, H											
	0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.600	0.800	1.000	1.200
W, width of bead	1/4	1/2	3/4	1	1-1/4	1-1/2	1-3/4	2	3	4	5	6
R_1, bead radius	7/64	7/32	21/64	7/16	35/64	21/32	49/64	7/8	1-/516	1-3/4	2-3/16	2-5/8
R_2, corner radis	0.070	0.140	0.210	0.280	0.350	0.420	0.490	0.560	0.840	1.120	1.400	1.680
R_3, blend radius	1/2	1	1-1/2	2	2-1/2	3	3-1/2	4	6	8	10	12
T, stock thickness (max) Rubber pad formed on hydraulic press	0.016	0.025	0.032	0.040	0.051	0.064	0.064	0.064	0.064	0.064	0.064	0.064
Punch and die formed on mechanical press	0.032	0.040	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
Roll formed on a bending machine	0.032	0.040	0.051	.....	.....	.....	.....	.....	.....	.....	.....	.....

Machine beading partially stretches and pulls the metal into female rollers, resulting in well defined bead shapes. A relatively high amount of stretching of the metal is permitted by the roll-forming action. This method of beading is slower than matched-die stamping or rubber forming and is not very practical on flat surfaces; yet, bead sizes and shapes are almost unlimited. The Yoder Mill is a good example of a machine for roll-bead forming.

Design Criteria

Good beading design calls for beads to be formed as deep as possible without fracturing the metal, consistent with reasonable tooling costs and the ability to achieve high production without rejects. The design data supplied in Tables I to VII are based on actual experience, and fulfill this design criteria. In no case should forming radii be specified which are less than the values given in Table VII for the particular material being formed.

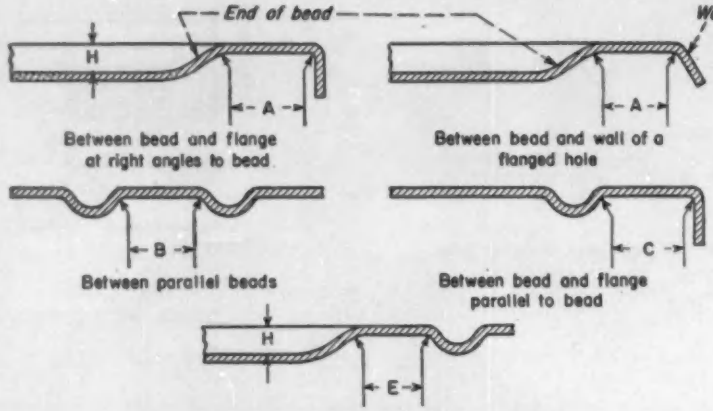
Straight through beading design data are given in Table I. These data apply whether one or more beads are formed at a time. Such beads are usually brake formed. Spacing between beads should not be less than 1 in.

Inside beading, where the beads begin and end within the edges of the sheet, should be designed according to data in Table II. Bead ends must blend into the flat sheet surfaces through use of generous radii, to prevent distortion and warping. Such distortion is most severe when a part is quenched after heat treatment and will usually occur near a flat edge without a flange. Values of blend radii given in Table II are reasonable minimum design values, but larger radii can be specified at some sacrifice in reinforcing strength.

Spacing of beads should be as close as possible to give maximum strength and to avoid wide flat areas which are inherently weak; yet there is a minimum spacing which will allow full bead formation without fracturing the metal. Table III supplies spacing design data.

Corner beading, which is stamping of beads into the corners or heels of formed sheet-metal angles, as shown in Fig. 3, greatly increases structural stiffness and replaces customary gussets. Such beading can be applied to high-strength aluminum alloy angles in heat treated condition without danger of cracking. Preformed angles can be corner beaded at any desired place by using a steel die in a punch press.

Table III—Spacing Design for Inside Beads


End of bead
Wall of flanged hole
H
A
Between bead and flange at right angles to bead
Between bead and wall of a flanged hole
B
C
Between parallel beads
Between bead and flange parallel to bead
E
Between two beads at right angles to each other

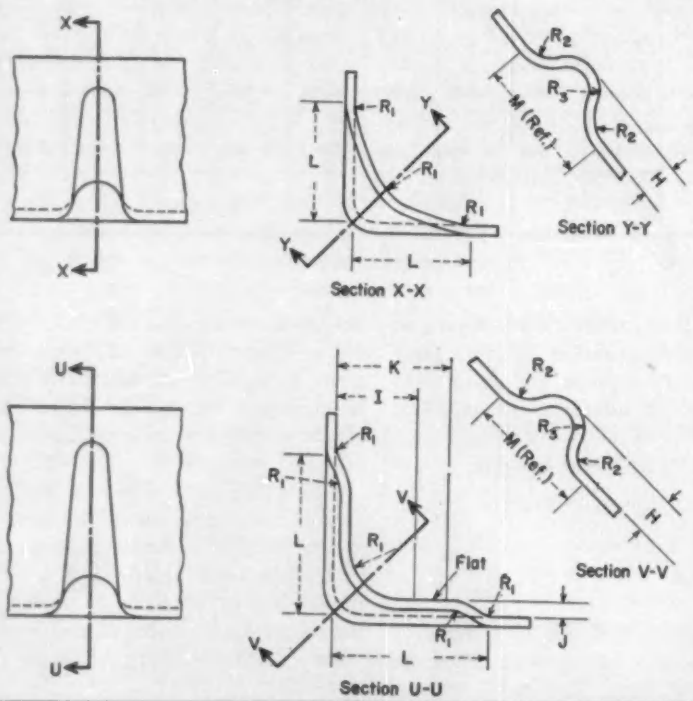
Dimension	Design I	Design II
A	2H	3H
B	8H	16H
C	5H	10H
E	3H	5H

H = height of bead as determined in Table II

Design I: Applies when material is annealed, when bead is formed on same side of sheet as flanges, and forming is done in rubber.

Design II: For any conditions not falling in Class I

Table IV—Corner bead designs



Design Data

Size L	Type	R_1	R_2	R_3	H	M (ref)	I	K	J	Spacing between beads
1/2	1	1/4	23/64	3/16	1/8	23/32	.....	.....	.....	2-1/2
3/4	1	5/16	41/64	17/64	13/64	1-5/32	.....	.....	.....	3
1-1/4	2	11/32	55/64	21/64	17/64	1-1/2	55/69	15/32	1/8	3-1/2

Dimensions are in inches; tolerance on H is −1/32.

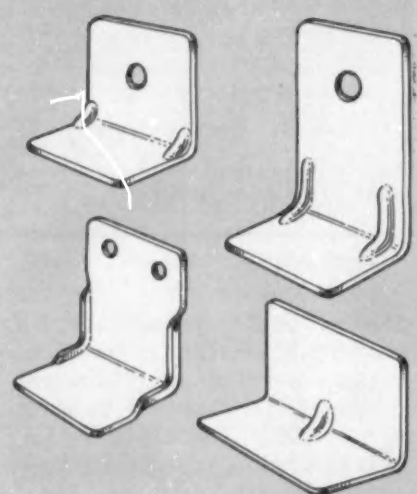


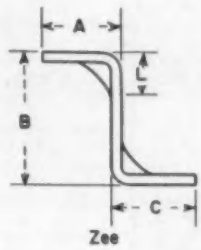
Fig. 3—These angles are greatly reinforced by use of corner beading; yet no weight is added, and production cost is low. For detailed data on designing angle beading, see Tables IV and V.

Table IV shows details of good corner bead design for three sizes of beads in high-strength aluminum alloys.

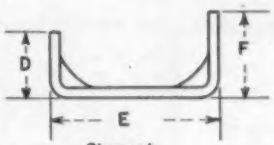
For low carbon steels, a much more defined and deeper bead can be used since the elongation is much higher and the metal is therefore less subject to fracturing. Yet, in order to standardize tooling it is often advisable to

Table V—Corner Bead Design Data

For high production in a mechanical press



Zee



Channel

Shape	BEADS IN ONE ANGLE ONLY Allowable dimensions, in.—for bead size L shown		
	L = 1/2	L = 3/4	L = 1-1/4
Zee	A—From 5/8 to 9-1/4 B—From 1-3/4 to 9-1/4, and C from 0 to B + 2-1/4; *or* B—7/8 or greater with C such length that B + C, including bend allowance, does not exceed 9-1/4.	A—From 7/8 to 9-1/2 B—From 2-1/4 to 9-1/2, and C from 0 to B + 2-1/8; *or* B—1-1/8 or greater with C such length that B + C, including bend allowance, does not exceed 9-1/2.	A—From 1-3/8 to 9-5/8 B—From 3-1/8 to 9-5/8, and C from 0 to B + 2; *or* B—1-5/8 or greater with C such length that B + C, including bend allowance, does not exceed 9-5/8.
Channel	D—From 5/8 to 9-1/4 E—1-1/2 min to 9 max, and F from 0 to E/2; *or* E—7/8 or greater with F such length that E + F, including bend allowance, does not exceed 9-1/4.	D—From 7/8 to 9-1/2 E—1-3/4 min to 9-1/4 max, and F from 0 to E/2 max; *or* E—1-1/8 or greater with F such length that E + F, including bend allowance, does not exceed 9-1/2.	D—From 1-3/8 to 9-5/8 E—2-1/8 min to 9-3/8 max, and F from 0 to E/2 max; *or* E—1-5/8 or greater with F such length that E + F, including bend allowance does not exceed 9-5/8.
	BEADS IN TWO ANGLES		
Zee	A—From 5/8 to B 2-1/4, but no greater than 9-1/4. B—From 1-3/4 to 9-1/4. C—From 5/8 to B 2-1/4.	A—From 7/8 to B 2-1/8, but no greater than 9-1/2. B—From 2-1/4 to 9-1/2. C—From 7/8 to B 2-1/8, but no greater than 9-1/2.	A—From 1-3/8 to A 2, but no greater than 9-5/8. B—From 3-1/8 to 9-5/8. C—From 1-3/8 to B 2, but no greater than 9-5/8.
Channel	D—5/8 min to E/2 max. E—1-3/4 min to 9 max. F—5/8 min to E/2 max.	D—7/8 min to E/2 max. E—2-1/4 min to 9-1/4 max. F—7/8 min to E/2 max.	D—1-3/8 min to E/2 max E—3-1/8 min to 9-3/8 max. F—1-3/8 min to E/2 max.

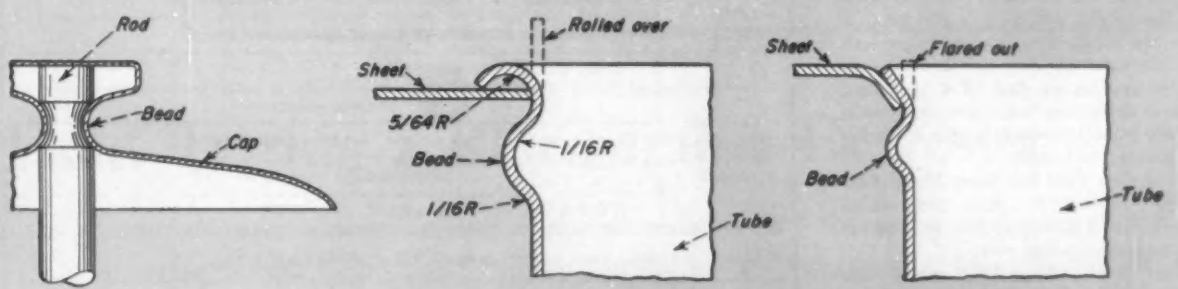


Fig. 4—(A) Assembly of a metal shell to a rod by spinning the metal cap into the groove in the rod. A tight, rotation-free assembly is produced; (B) rolled-over (left) and flared-out beading (right), show how tubing can be assembled to plate to make tight but easily assembled joints.

use the same bead for all materials. Table V gives design data for bead-reinforced "Z" and channel sections for high-quantity production at minimum tool cost, using the beads detailed in Table IV.

Tubing end beads are used extensively for hose connections. Design data for the most common sizes, ¼ to 3 in. dia., are given in Table VI.

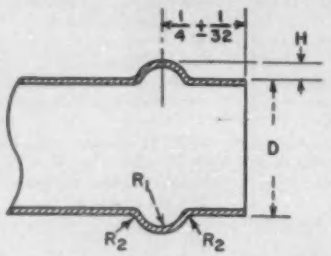
Beads for assembly, by the interlocking of parts, can often replace costly riveting, welding, or soldering. For example, the fastening of a metal shell to a rod, as at A in Fig. 4, is done by spinning. The rod is grooved, then chucked in a lathe while the metal cup is placed over the rod and held clamped in place by a wood block mounted on the lathe tailstock; the metal is then spun into the groove, producing a tight, rotation free, assembly.

In another example of beads used for assembly, *B* in Fig. 4, a tube is fastened to a flat sheet. A bead is formed near the end of the tube; after

inserting the tube through the hole in the sheet, the edge of the tube is rolled over in the first design. The flared design, right, is another approach to the same problem.

Table VI—End-hose beading design

(For 1/4 in. to 3 in. dia tubing and using standard tooling)



Tube dia *D*	Bead height *H* (tol. ±0.003)	Bead radius R_1 (max)	Corner radius R_2 (max)
1/4	0.031	1/8	1/16
3/8	0.035	1/8	1/16
1/2 to 3/4	0.038	1/8	1/16
1 to 1-1/4	0.062	5/32	3/32
1-1/2 to 1-3/4	0.072	5/32	3/32
2 to 3	0.082	5/32	3/32

EDITOR'S NOTE—This is the first of a series of two articles on sheet metal beading. The second will give design data for waffle and lattice-type beading to provide high structural rigidity in all directions.

These articles are part of a continuing series on designing functional sheet-metal parts for producibility at lower costs. Recent articles included:

"23 Design Tips For Sheet Metal Fabrication", May 1955, page 166, which listed the many design factors to consider in cutting fabricating costs.

"Sheet Metal Design With the Dollar Sign in Mind," Oct. 1953, page 188; in which bend and hole tolerance considerations were discussed in detail; also the importance of standardizing on flange and corner-notch dimensions.

"Basic Design For Small Parts Stampings", Jan. 1952, page 162, presented ideas for design of relief notches for right angle bends, and location of pierced holes relative to such bends.

Often overlooked points in design were discussed, including the use of stock warehouse dimensions where possible; specifying maximum possible tolerances on dimensions; use of standard fasteners; reduction in number of pieces in the overall assembly; minimizing of expensive welding operations; use of sandblasting for cleaning; avoidance of holes close to right-angles bends; use of punched ribbing for strengthening wherever possible; the use of extruded members for complex shapes; and other factors.

Table VII—Recommended Minimum Bend Radi. for Sheet Metal

(A) ALUMINUM ALLOYS

Material		Minimum Radius, in.		
		1/8	3/16	1/4
Type	Condition	Sheet Thickness, in.		
7075 (75S)	0	0.016–0.072		
	T6	0.016–0.025	0.032–0.051	0.064
2014 (14S and R301)	0	0.016–0.072		
	W	0.016–0.064	0.072	
	T	0.016–0.040	0.051–0.064	0.072
2024 (24S) (Note 1)	0	0.016–0.064	0.072	
	T4	0.016–0.051	0.064–0.072	
	T3	0.016–0.032	0.040	0.051
6061 (61S)	0	0.016–0.072		
	T	0.016–0.064	0.072	
5052 (52S)–0; 1100 (2S) up to 1/2 H; 3003 (3S) up to 1/4 H		0.016–0.072		

Note 1—2024 alloy, 0.064 gage, min. bend radius is 5/16 in.

(B) MAGNESIUM ALLOYS

Material	Minimum Radius, in.			
	1/8	3/16	1/4	5/16
DOW Ma AM C52S-0 DOW FS-1a	70 F forming temperature			
	0.016–0.025	0.032–0.040	0.050–0.063	0.071
	400 F forming temperature			
	0.016–0.063	0.071		
DOW Mh AM C52S-H DOW FS-1h (Note 2)	70 F forming temperature			
		0.016	0.020–0.025	0.032–0.040
	400 F forming temperature			
	0.016–0.040	0.050–0.063	0.071	

Note 2—For 0.050 in. stock, at 70 F, radius is 3/8 in.: 0.063 stock, 1/2 in.

(C) STEEL

Material		Minimum Radius, in.			
Type	Condition	1/32	1/16	1/8	3/16
Corrosion-resisting steel	Annealed	0.014–0.030	0.036–0.048	0.060–0.075	
	1/4 H		0.014–0.042	0.048–0.075	
	1/2 H (Note 3)		0.014–0.024	0.030–0.042	0.048
	3/4 H (Note 4)		0.014–0.018	0.024–0.048	0.060
	H		0.014–0.018	0.024–0.030	0.036–0.048
4130 Steel	Annealed	0.014	0.018–0.048	0.060–0.075	
	Normalized	0.014–0.024	0.030–0.042	0.048–0.060	0.075
Low-carbon steel			0.014–0.060	0.075	

Note: 3—Min radius for 0.060 in. stock, 1/4; 0.075 stock, 5/16
4—Min radius for 0.075 in. stock, 5/16.

TESTING FOR PRODUCT PERFORMANCE

To develop a product requires: Market research, design specifications, basic preliminary design, test program, and design modifications, if necessary. In the test program, initial tests are made on a limited number of experimental models. Criteria met, tests are then applied to units manufactured on a short production run.

Each test series requires: Complete and accurate measuring apparatus, duplication of average and extreme field conditions, determination of optimum length of test period, and efficient means of data control and collection.

The two case histories presented here emphasize the importance of integrating field and laboratory testing, as well as duplicating actual service conditions.

Field Testing a Refrigerator Defroster

How field data obtained in the design of an automatic defrosting refrigerator improved laboratory testing methods and furnished guide to the development of an entire product line.

G. S. McCLOY

Electric Appliance Engineering Dept., Westinghouse Electric Corp.

THE AIM of any automatic defrosting system is the frequent removal of frost accumulation for efficient evaporator operation. First efforts to design an automatic defrosting unit made use of a clock-switch mechanism to interrupt power for a pre-set interval once every 24 hours. Samples placed in the field revealed deficiencies; no automatic compensation was provided for different rates of frost collection. Ice cubes were contaminated, frozen foods improperly kept, and evaporator defrosting was incomplete. Moreover, no automatic method of water disposal was available. Defrost water was allowed to accumulate in a food storage pan, or collected in a vessel which required periodic emptying.

Design of an effective and fully automatic defrosting refrigerator was specified to furnish 1) Rapid frost removal; 2) timely initiation and termination of defrost cycle; 3) automatic disposal of defrost water. A refrigerator must function under widely varying load requirements of a single user or a larger household—in hot humid summer conditions and winter household temperatures.

Laboratory study found that frost build-up was influenced by the frequency and elapsed time of door openings, in addition to the temperature and moisture content of the ambient air. Identical factors were found to affect the rate of water evaporation.

To ascertain average and extreme operating conditions, field data was necessary. User habits and the intangibles peculiar to a home, such as dust and grease, required evaluation. A systematic test program was organized.

The refrigerator equipped with the clock-switch defrost mechanism was used for the first field test model. Families of varying size and character participated in the program.

Table I—Test Data From Two Typical Locations

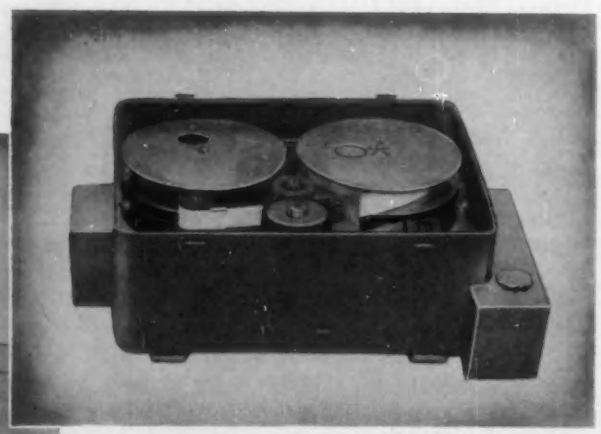
Size of family		3 adults 3 children	2 adults
Test period		18.5 days	19 days
Door openings, total		1283	421
per day		69	22
Time open, total		253 min	73 min
average		11.5 sec	10.5 sec
Time Distribution of openings			
Forenoon	6:00 to 9:00	15 (22%)	6 (27%
	9:00 to 11:00	5 (7%)	1 (4%)
Afternoon	11:00 to 1:00	12 (17%)	5 (23%)
	1:00 to 5:00	10 (15%)	2 (8%)
Night	5:00 to 8:00	22 (32%)	7 (34%)
	8pm to 6am	5 (7%)	1 (4%)

Load test areas were selected that would assure operation under a wide variety of climatic conditions. Greatest emphasis was placed on southern areas of the country having most severe temperature and humidity conditions. Suitable instrumentation was provided. A mechanical counter actuated by the refrigerator door tabulated openings; a clock-driven tape recorder, shown in Fig. 2, indicated the elapse time and distribution of openings over a given period. To evaluate defrost water evaporation a weather study was conducted; the country was divided into areas on the basis of rates of water evaporation, shown in Fig. 1. Units were concentrated in areas where the condition was most severe. Throughout the testing conditions were checked with local weather bureaus.

Field test results, samples shown in Table I and Fig. 3, guided the engineering staff in evolving a design that related initiation of the defrost cycle to the number of refrigerator door openings. The length of the cycle was related to the evaporator temperature. Warm air currents produced by the motor were used to evaporate the defrost water.

Over a period of approximately four years, a limited number of experimental refrigerators were built and put on field test, using the basic elements of the final design. The refrigeration-defrosting system introduced no additional moving elements, retained the major components of the standard units, and was characterized by simplicity of manufacture. The defrost control was responsive to

Fig. 1—Map used to guide choice of test site locations. Shadings represent relative rates of water evaporation. Dots mark locations of sites during one phase of field operations. Note diversity of climatic conditions of the test site locations.



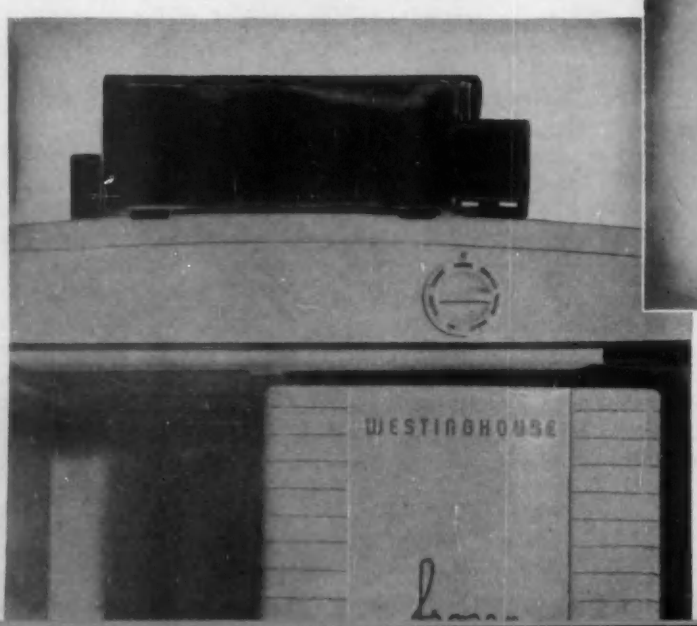


Fig. 2—Electric clock-driven tape unit mounted on refrigerator. Unit was used to record the number, duration and distribution of door openings during a given time interval. Distribution data was made possible by constant speed drive.

frequency of door openings and evaporator temperature; defrost water evaporation was provided for by a pan located in the motor compartment.

Several hundred units were then produced on a short-run basis, and given a year's test in areas imposing the most severe operating conditions. Final refinements were made, and full-scale manufacture begun, introducing the first fully automatic defrosting refrigerator.

During the course of the field tests, samples were first placed in the home of engineers associated with the product development. As the program was expanded, units were added to the homes of key service personnel. Technically trained persons familiar with the product provided accurate reports easily interpreted. Refrigerators were also located in homes of employees not directly affiliated with the development program and in homes of non-employees. Performance data was collected on forms given the users for periodic submission. Inspections were made by local service organizations and engineers on field trips. The information acquired was applied to the improvement of the entire company line of domestic refrigerators.

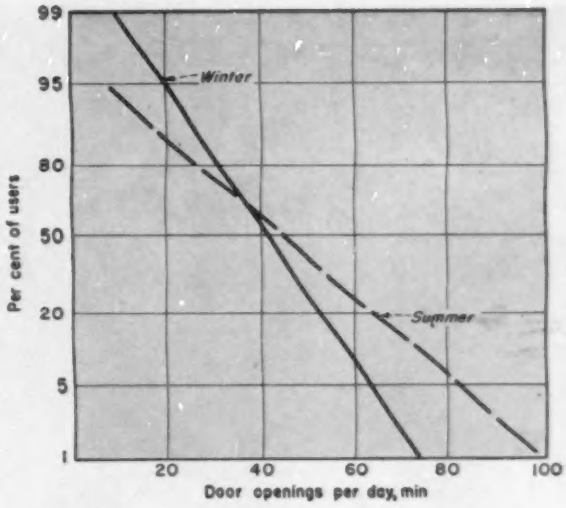


Fig. 3—Comparative distribution of user habits in summer and winter months for one refrigerator test location.

Duplicating Service Conditions

Performance specifications must adequately represent service conditions if the designer is to properly safeguard a product. Unforeseen shock, vibration, temperature, humidity, and aging effects are threat to product reliability.

H. E. MENDOZA
Aircraft Products Dept., General Electric Co.

PRODUCT FAILURES are almost invariably due to a lack of accurate performance specifications in the design stage. Radios, automobiles, and typewriters have service lives that may be reliably simulated. However, military equipment and particularly aircraft equipment, experiences conditions much more difficult to predict and the consequences of failure are more critical. This equipment is expected to operate under varying conditions of shock, vibration, temperature, humidity, altitude, sand, and dust, independent of its location, mounting, or attitude.

The designer is, therefore, faced with a nightmare of design and requirements, but is seldom provided with specific information on expected service conditions. Government specifications are often too general and unrealistic. For example, in the design against shock and vibration, the specification information must cover the requirements for equipment in many different aircraft applications. For reliability, however, information on the actual mounting conditions of the equipment in the aircraft, the equipment attitude, the actual aircraft vibration frequencies under all engine speeds, maximum landing shock at the equipment location and other such essential features are needed. This is not generally made available, often because the aircraft in which the equipment will be mounted is in its initial design stages, and the reliability of delicate components is greatly impaired.

To illustrate, an electronic control amplifier designed for a modern all-weather interceptor was required to meet a 10 g maximum shock specification. However, due to its location and mounting in the aircraft—approximately 7 ft forward of the landing gear, and air frame mounted with a rather poor shock isolation system—some of the tubes were found to have received shocks in excess of 50 g.

Specification requirements on simultaneous humidity and temperature conditions must also be clearly defined. Ambient temperature defines nothing if conditions of stagnent air or circulation around the equipment is unknown. Humidity through condensation is different from humidity through rainfall or water spray.

A clear example of this situation occurred in an electronic system for an engine control. The equipment was air frame mounted in an interceptor. The initial design specification issued by the customer required satisfactory operation after 15 days in an atmosphere of 95 per cent relative humidity with temperature variations of 70 to 130 F. No power was to be applied to the amplifiers while in the wet condition. After completion of the 15 day soak, a 36 hour free convection drying period was permitted before operation of the equipment was required. In actual service it was found that due to equipment location and water leakage of the air frame, the equipment was subjected to water spray (100 per cent RH). Also, since it was for an interceptor, operation was required at any instant under all conditions.

The above equipment upon release to the field was expected to withstand all operational requirements regardless of how closely they were correlated with the design

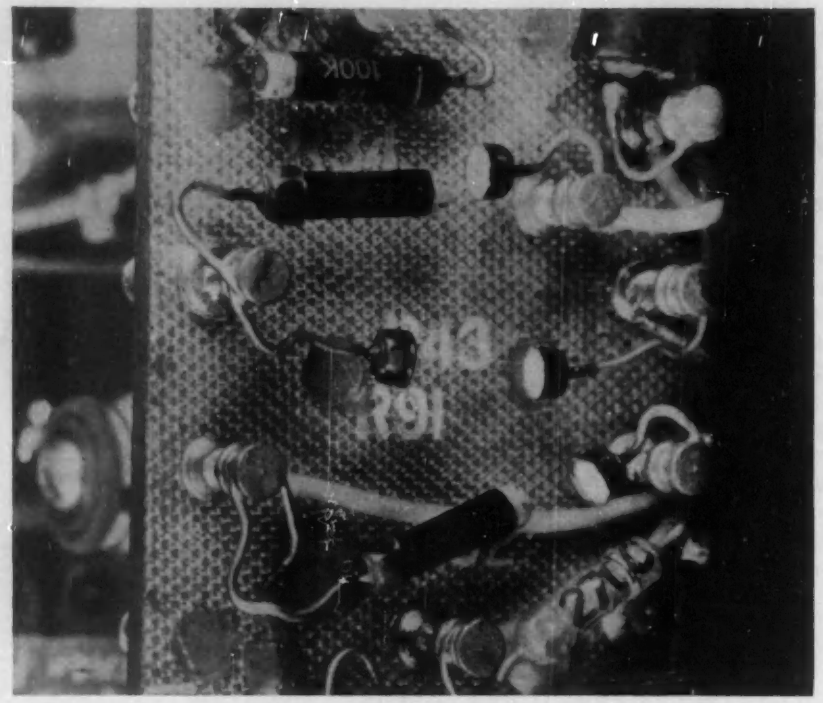


Fig. 1—Actual service photo of an amplifier mounting board where stress corrosion caused resistor end caps to split open. Element R-43 has fallen free of both end caps.

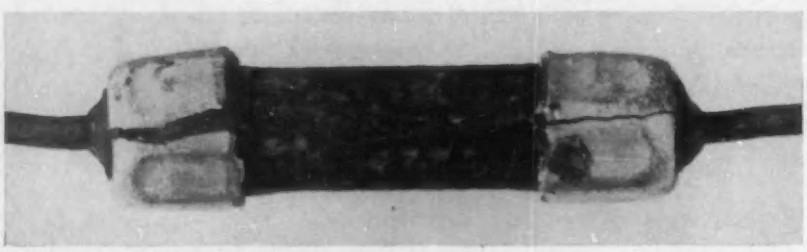


Fig. 2—Resistor that has undergone an accelerated life test using a 1 per cent mercurous nitrate solution. End cap material which had stresses created in manufacture will show obvious cracks within seconds. The time that the resistor can withstand immersion can be approximately correlated with life in service.

specifications. Naturally, the equipment failed. If more accurate field information had been made available early in the design study, a needless malfunction could have been prevented, and better reliability could have been designed into the equipment.

Without the aid of field and service information, equipment tests performed at the factory often miss information essential to the design group in determining life under actual application conditions. It is often difficult to simulate aging of materials in any factory test. For example, component failures due to stress corrosion of materials may go undetected unless some simulating test can be devised.

One prominent failure due to this stress corrosion factor occurred in the use of a deposited carbon type of resistor which had end caps pressed onto a ceramic rod. After a short service life of approximately 6 to 12 months, the resistance element would break loose from the end caps and fall free as shown in Fig. 1. Field service supplied samples which were analyzed at the factory and the cause determined. The caps for the elements were manufactured in a single drawing operation. This created stress corrosion cracks in the material in time, and the pull-off force decreased to zero in many cases. Military specifications required a 5 lb pull-force on the resistor, but when new, the resistor met these requirements. Factory testing with temperature and humidity cycling for short periods of time missed this important potential failure. It was not until field service data revealed the problem that a simulating test could be devised.

An accelerated life test for stress corrosion can be simulated by dipping the resistor in a 1 per cent solution of mercurous nitrate. Under these conditions cracks and stresses became evident within seconds as shown in Fig. 2. Through work with the resistor manufacturers it was possible to change the material composition of the end cap to eliminate the stress problem. A permanent factory test has also been set up to make an accelerated life test to determine the life possibilities of the component materials.

A very similar fault was detected on tubular metallic can type capacitors. The material used to form the can was prepared by a rolling operation which again created material stresses. With age, cracks appeared which caused leakage of the dielectric fluid. The same mercurous nitrate test provided a means of checking the life possibilities of the item, and work with the manufacturer revealed that the stresses could be relieved in an annealing process after rolling.

Components may pass all factory vibration, temperature and aging tests successfully, but fail within a short time under service conditions. In an electronic application for an aircraft, field reports indicated excessive failures in one winding of a power transformer. The transformer met all requirements of MIL-T-27, and a factory performance test indicated it would withstand vibration, humidity, altitude, and temperature cycling. Yet, within 1 or 2 months of service a secondary winding (and it was the same winding at all times) would be found open. Factory attempts to cause the failure were unsuccessful. The transformer was cycled thousands of times at full load and overload, input voltage and frequency were varied and many other tests were tried. In desperation, the wire size of the winding was increased in the belief that possibly unknown transients were causing severe overloads; however, service failures persisted. Finally, it was discovered that since the end terminations of this particular winding were imbedded in the transformer encapsulating compound, the differential temperature coefficient of expansion of the potting compound and the wire was such that

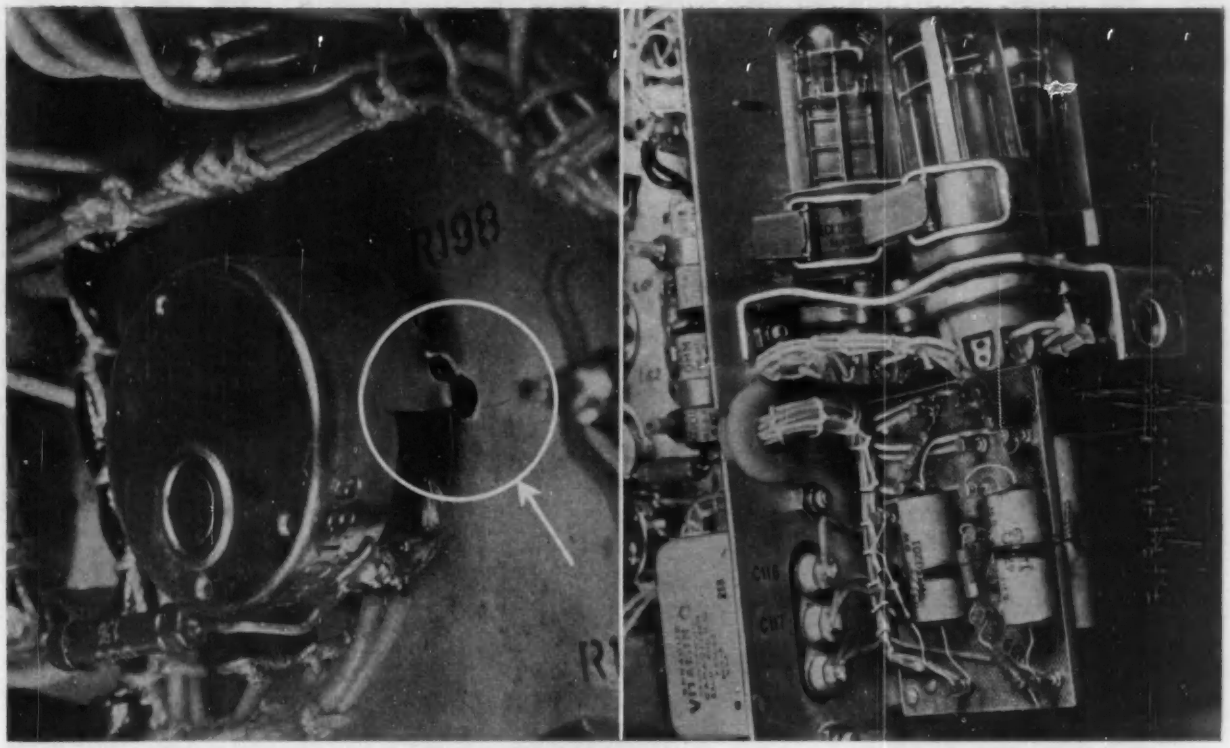


Fig. 3—Two typical field failures which clearly show the cause of failure. Left, potentiometer with a locking device has been over-torqued; failures of this type are often undetected unless wires are broken or shorted. Right, bent tube shelf and bottom cover of this amplifier show evidence of a severe blow; tubes on shelf are inoperative because of the shock.

under prolonged temperature variations the expanding compound caused excessive stresses in the wire and eventually pulled it apart. An extended temperature test was set up under which the transformer was subjected to 10 cycles of temperature variation from 125 to −55 C. Failures began occurring in the 5th, 6th, 9th and 10th cycles in the same winding and it was the same type of failure. After this verification of the fault, test on an improved transformer indicated the end of the trouble.

The information which the designer receives from the field must include specific data to be of value in the correct analysis of component or equipment failures. Maintenance personnel or field service representatives must make their reports as detailed as possible. Descriptions of chronic failures are most valuable, and in these cases it is important to know the conditions under which the equipment failed. The designer can then establish simulated test conditions to verify the failure and determine whether the application rather than the service conditions were the cause. The report should state the circuit component number, the component type, value and part number, type of failure, and equipment type and number. If an elapsed time indicator is available on the equipment, the actual service time should be reported; if not, an accurate estimate of the service life in actual operating time should be attempted. This will aid in establishing faults due to aging features, or will determine the necessity for improved life requirements of the component or the equipment.

Samples of components returned from the field due to malfunction are helpful in improvement attempts, and the field service teams should return as many of these as possible for proper fault analysis. These returned components often supply the information necessary to establish the reason or cause of the malfunction, as in the examples in Fig. 3. Some returned components such as connectors with bent or broken pins, miniature tubes with bent pins, switches with broken stops, etc., establish the need for equipment handling instruction to avoid gross mishandling or misapplication of the equipment in service.

It then becomes the task of the design engineer to get the most out of information which is supplied by the field maintenance groups. The most common method is to keep a tabulated running form of component failures or equipment performance symptoms in order to determine reliability or failure trends and potential performance characteristics. This tabulated data pinpoints components or equipment that suffer the greatest number of malfunctions with time. Lines of communication between the design engineer and the component manufacturer are shortened by returned component samples, and it is possible to initiate component improvements or manufacturing revisions. A thorough review of the field information on equipment operating circumstances will definitely establish correctly simulated test conditions for elimination of potential field failures at the point of manufacture.

The importance of field information in the study of component reliability cannot be too greatly emphasized. The design engineer must be aware of the conditions a design is expected to meet and survive, or the service life of the item is greatly reduced. More reliable and less costly equipment can and will be designed if the expected conditions of service are supplied.

TECHNICAL NEWS

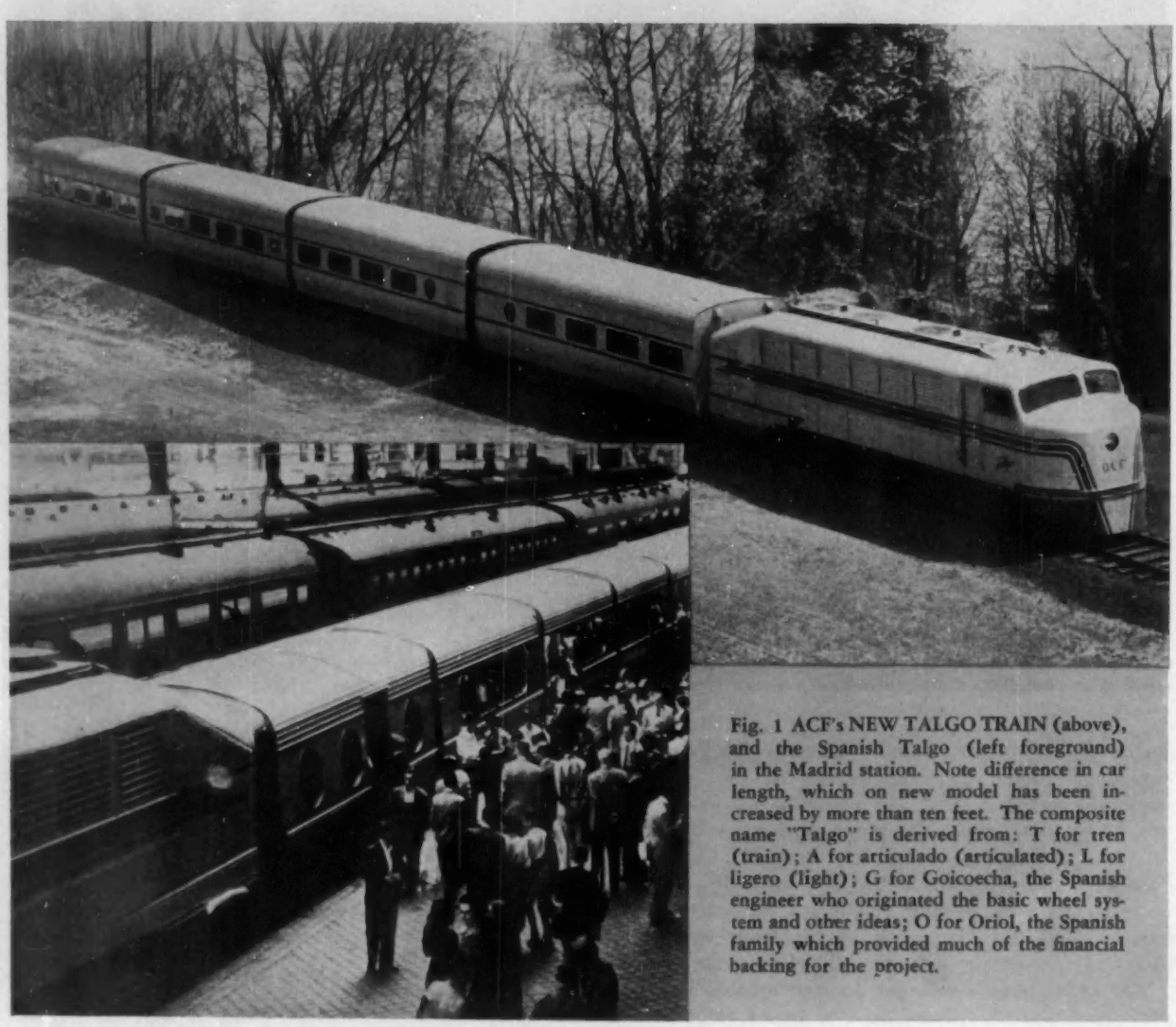


Fig. 1 ACF's NEW TALGO TRAIN (above), and the Spanish Talgo (left foreground) in the Madrid station. Note difference in car length, which on new model has been increased by more than ten feet. The composite name "Talgo" is derived from: T for tren (train); A for articulado (articulated); L for ligero (light); G for Goicoecha, the Spanish engineer who originated the basic wheel system and other ideas; O for Oriol, the Spanish family which provided much of the financial backing for the project.

Spanish Talgo Ready For U. S. Railroads

About a year ago, ACF Industries, Inc. exhibited to the public the Spanish Talgo train, the light-weight, high-speed train that was being operated with great success on the 400-mile run between Madrid and the French border. Tested on the New Haven Railroad, it reached a speed of 111 mph and was hailed as the answer to the railroad's prayer. Since then everybody has been getting into the act. Many railroads—and one or two aircraft companies—announced their version of a new "streamlined, lightweight train." But when pressed for details or illustrations on the subject, not too many were forthcoming.

ACF, confident that they were on the right track, redesigned the Talgo to fit American operational requirements, Fig. 1, and sold it to the Rock Island Railroad. Scheduled to go into service this fall, it will cut the running time on the 161 mile route between Chicago and Peoria. The New Haven Railroad has also announced that it will buy one of ACF's Talgos for use on its Boston-New York run.

The Talgo train developed from the idea that useless dead weight was not needed to keep a train on the rails, and that higher speeds and greater economy of operation could be attained if this weight could be eliminated. The following design characteristics were developed: lower center of gravity; light weight; and the guided axle principle. This guided axle principle is compared to a trailer truck with its two trailing wheels and the one steering and pulling coupler, Fig. 2a.

In the conventional wheel assembly, Fig. 2B, the double axle truck is free to rotate on the bottom of the car,

and when going around a curve, the flanges of the leading wheels dig into, and try to climb over the rail. This is what railroad men call the "positive angle of attack," and which is opposed by the weight of the car to keep the wheels on the track.

In the Talgo principle, the ratio of the length of the car to the track gauge is held to a proportion, which, in curves, results in the trailing flange of the wheel keeping in contact with the rail, and holding the wheels down. This is called the "negative angle of attack," Fig. 2C, and reduces the tendency to derail. Mathematically, the optimum car length worked out to about 30 ft. for U. S. gauge track.

However, this principle meant that the cars could operate in one direction only, and that the entire train must be turned around. At a dead-end station, this presented difficulties. Also, with each car having only two wheels, handling in the yard was a problem.

ACF's big problem, then, was to keep Talgo's basic principles, but make the cars reversible. This was accomplished with a three-car unit which is completely interchangeable and which always operates as one unit. Two of the cars are the conventional Talgo two-wheelers, attaching to each end of the center car which has four wheels, Fig. 2D. A schematic diagram of a special linkage arrangement is shown in Fig. 2E.

Length and weight comparisons are shown in the table below pointing out the economies of a small train operation. While the Talgo design permits high speed operation, ACF says that the big savings in time will be in greater speeds on the curves. The reduced car weight, 70,000 lb. as compared to the 140,000 lb. for the conventional car, (see chart) will cut the deceleration time necessary when approaching a sharp curve, and the acceleration time after rounding it. ACF says that the car weight could be reduced still further, except that American railroad requirements state that all cars must be able to take a buff load (longitudinal loading of the under frame) of 800,000 pounds. The Spanish Talgo weighs half as much as the new Talgo, but was required to meet buff loads of only 50,000 pounds.

Materials used in the new car are a low-alloy, high-tensile steel structure with an aluminum alloy superstructure. Stainless steel for the exterior skin is also possible.

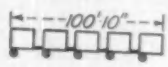
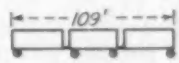
	Conventional Car	Old Talgo Car	New Talgo Car
Car Height	13′ 6″	9′ 6″	10′ 10″
Floor Height (from rails)	4′ 4″	1′ 6″	2′ 2″
Center of Gravity	5′ 4″	3′ 4″	3′ 6″
	85′	100′ 10″	109′
Consist			
Weight	140,000 lb.	35,000 lb.	70,000 lb.
Passengers	64–84	64–84	84–96
Buff load (test load requirement at underframe)	800,000 lb.	50,000 lb.	800,000 lb.

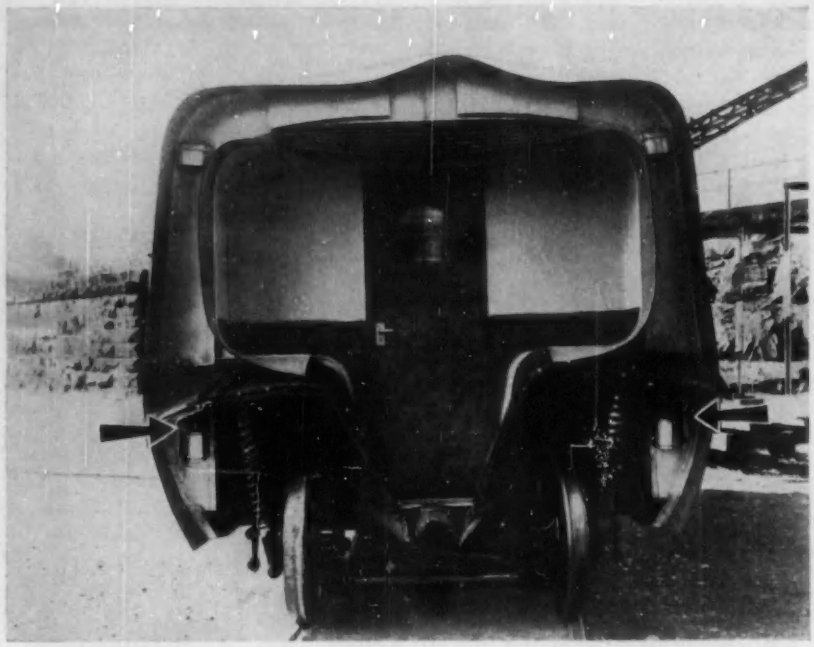
Fig. 2

WHEN THE LONGER (85 ft), conventional railroad car (B) goes into a curve, its centrifugal force makes the flanges of the wheels bite into the rail, and tend to make them climb the rail. Called the "positive" angle of attack, its only counter action is the weight of the car. With the Talgo principle (A, C), the trailing flange of the wheel contacts the outer rail reducing the tendency to climb the rails. Two-wheel suspension also shows up in weight savings, with a reduction in the size of motive power. ACF's design for the U. S. Talgo (D), consists of a three-car unit which is completely reversible, and which always operates as one unit. Wheels are not only guided, (Talgo principle) but steered as well, so that the wheels are always tangential to the tracks. This is accomplished through a linkage device which ACF will not reveal. However, the schematic diagram (E) shows basic idea. When two cars are on a curve, they form an angle (Y) between them which is related to the curve. Working from this angle, a special linkage arrangement keeps the axles at right angles to the curve at all times. Basic principle shows wheels in position (a) (center of angle), and linkage would be as shown. But with wheels in correct position (b), special allowances must be made. With this arrangement, the wheels have a zero angle of attack on the rails.

The suspension system and axle arrangement shown at right is that of the old Talgo. ACF, at present, is not showing, nor divulging, any of the secrets of the new system other than saying that it is based on the same principle. Particularly, they will not reveal how they solved the problem of wheel shimmy at high speeds.

An integrated air-brake system is used with reservoirs located in each three-car unit. Brake equipment is of the internal expanding automotive type. Earlier brakes were hydraulic.

The locomotive is of special design to conform with the lower passenger cars. It will be designed and built by the Electro-Motive Div. of General Motors Corporation. Propulsion power will be a conventional 1,200 hp diesel-generator. Also found in the locomotive are two auxiliary diesel generator sets with a total output of 200 kw for the auxiliary services (lights, air-conditioning, heating). For this purpose, batteries and generators are usually found in the conventional cars. Total weight of the new locomotive will be about 30-40 per cent less than the conventional design.



THE REAR, OR WHEEL END of the old Talgo coach. Arrows show the vertical load absorbing carry-through-members which takes the weight of the front of the car behind, which is attached at this point. In curves, these members slide in and out of rubber mounted bushings mounted in the front of the trailing car. The axle is stationary with the wheels rotating independently. The axle is dropped down to the lowest possible point, permitting the floor to be moved down between the wheels, giving a lower overall height, and a lower center of gravity.

New Chrome Plating Process

Using a new process, United Chromium, Inc., 100 East 42 St., N. Y. 17, N. Y. is depositing a chromium plate, free from pores and cracks, directly on steel, without using an undercoat of nickel, or copper and nickel. A much better resistance to corrosion than other chromium is claimed. Called Crack-Free chromium, the plating also has a low coefficient of friction, good adhesion, a non-galling surface, and excellent ductility.

The plating is done with a special chromic acid type bath having automatic regulation of the catalyst concentration. Standard plating equipment and procedures are used. The bath is prepared by dissolving the proper amount of a single compound, Unichrome SRHS Compound CF-500, in water. The same compound is used for maintenance. Plating speed is about the same as other chromium.

Softer and more ductile, the new plating was tested to 500-700 Knoop hardness, as compared to 800-1000 Knoop for other chromium. It remains crack-free when heated to 1000 F and then plunged into water. As a decorative finish, it is non-reflective in the unbuffed state, but can be polished in a buffing operation.

NYU Offers Master's Degree in Nuclear Engineering

The New York University College of Engineering just announced plans for a program in nuclear engineering for which the degree Master of Nuclear Engineering has been authorized. In conjunction with this is the scheduled construction of a sub-critical nuclear reactor for laboratory use.

It was said that the reactor would be the first of its kind at a university. It will consist of a 5-ft. tank of water in which two tons of uranium rods are placed. The neutron source of polonium and beryllium will be housed below floor level and can be hoisted up among the uranium rods by remote control. The reactor will operate at 1/300 of a watt, as compared with the 500-million watt unit proposed by Consolidated Edison. Neutron intensity will be about 100-million neutrons per sec., enough for such experiments as foil irradiations and geiger counter studies.

The reactor cannot maintain a chain reaction, and is safe for classroom studies in undergraduate and graduate education in nuclear engineering. Cost of the unit would be a few thousand dollars. However, the uranium would be on loan from the Atomic Energy Commission.

A second new degree that has been authorized at NYU is a Bachelor of Engineering Sciences. The program for this degree is designed chiefly for students intending to do post-graduate work directed toward research and development.

The postgraduate year in nuclear engineering consists of courses in: reactor engineering, chemical processing and isotope separation, reactor laboratory, reactor design, effects of radiation on metals and biological effects of radiation.

Engineers Again—This Time There is No Shortage

A soon-to-be-announced manpower report will deflate the flood of stories and the dire predictions concerning the general shortages of scientists and engineers in industry. Supported by the National Science Foundation, the report is based on a survey of scientists and engineers employed in industrial research and development. In the survey, more than 175 big firms who account for the bulk of the industrial research and development were covered.

According to information just received, the report will say something like this: "Scientist-Engineer shortages are exaggerated. The only real shortages—at least in research and development and maybe in all industry—are for people with much experience in very narrow specialties. This is mainly in the aircraft and electronics industries. There is no lack of young engineers and scientists fresh from college." About half the firms questioned said frankly that they are unaffected by manpower problems.

Chances are that the report will stir up much controversy. However, it will be welcomed by the military who has opposed special treatment for draftage scientists and engineers.

Beat Chevrolet!

—has been the byword of Ford Motor Co. executives for years, and last year Ford almost succeeded. In fact, total retail deliveries were so close between the two, that it was difficult to determine a winner. Now, Ford has made a move to set up as opposition all five of the General Motors car divisions, and Chrysler's five divisions as well.

Ford has split up the Lincoln-Mercury division, making each a separate entity. Then, the Continental Division was established out of the Special Products Div. which was set up to hide the development of the Continental, a $10,000 car scheduled for the market in August or September.

Ford, Lincoln, Mercury, and the Continental make four. Now, the Special Products Div. has been reactivated to start on the fifth car division. Although it will be renamed before it hits the market, the car is presently called the Model "E" (for Edsel). It is scheduled for introduction in 1957 or 1958, and will fit into the price gap between the Mercury and Lincoln. Its opposition will be the Oldsmobile 98, Buick Roadmaster, and indirectly the larger models of DeSoto and Hudson.

This is part of Ford's expansion program which was started after World War II, and to which the company so far has committed $1.7-billion. Ford is determined to get some of GM's share of the market, which in 1954 amounted to 52 per cent, while Ford's was 30.6 per cent. This year Ford has dropped to about 26.5 per cent because of Chrysler's comeback, which is presently taking about 19 per cent of the total industry output.

Output of the Continental probably will not exceed 2,500 in 1956, but Ford's only intent is to steal some of the thunder from Cadillac's reputation as the number one prestige car. Cadillac plans to combat this move by putting its El Dorado Brougham on the market within a year or so.

Self-Tapping, Sealing, Locking Nylon Nut

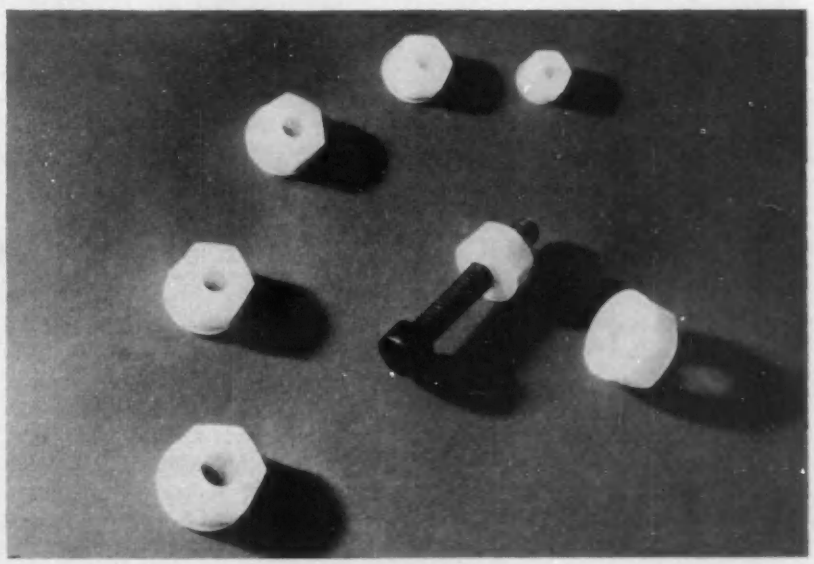
A new addition to the family of nylon products is this all-nylon hex nut molded from Du Pont Zytel 101 nylon resin. With a washer face and a sealing cone, the nut is simultaneously: self-tapping, locking, sealing, and insulating.

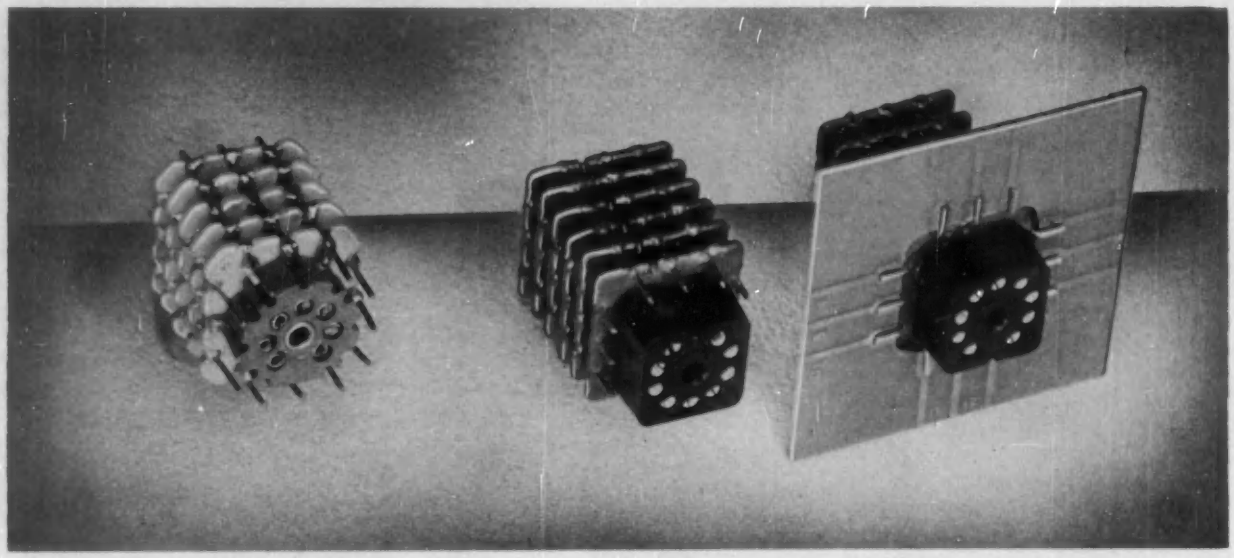
The internal bore of the nut, which has lead threads to admit the screw, creates a friction lock on the screw as the material is displaced by the drive torque applied to the screw. This action permits the nut to be pre-set at any point along the shank of the screw, and prevents any movement caused by vibration.

The feature of the nut is the cone at the bottom. When the nut is torqued down to the bearing surface, the cone cold flows into the clearance space between the screw and the walls of the hole. This seals the hole, prevents wobble and chatter, dampens noise and vibration, and adds to the static break-away values.

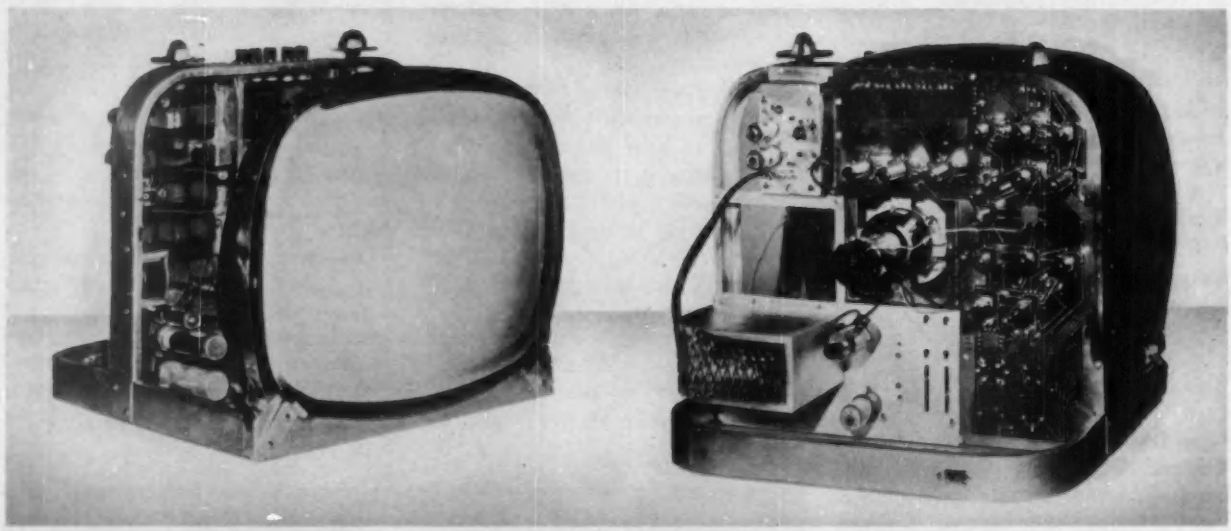
Called the Brilok Nylon Stop Nut, and made by the Brill Plastics Co, 46 Hopkins Ave., Jamestown, N. Y., the nut is stocked in sizes of numbers 4, 6, 8, 10, and ¼ in., at present. Color is ivory white, but special colors can be supplied for coding and ornomentation.

Reusable, the nylon nut is competitive with metal nuts in many applications. However, the manufacturer does not recommend its use where tensile loads are in excess of 10,900 psi at room temperature. Applications are in all types of equipment.





THE PROJECT TINKERTOY MODULE (left), the new ACF module (center), and the same module after it has been attached to a printed circuit board. All twelve riser wires protrude through "square hole", and with first wafer acting as a shoulder, a special tool spreads and locks the wires to the board. A dip-soldering operation follows. With two new plants under construction, ACF expects to handle one-third the module market for television sets (based on 100-million modules—15 modules per set).



FRONT AND REAR VIEW OF A COMPOSITE TELEVISION RECEIVER to show how the modular construction can be adapted to commercial items. Although cost of module is about the same as the unwired components it replaces, the savings will accrue in product's assembly. This 21-inch receiver has 195 component parts, plus the tuner. Of the 195, 153 parts are packed in 17 modules. The remaining 42 parts are represented by electrolytic capacitors, hardware, tunable parts, and others.

Modules: Good Things in Small Packages

Project Tinkertoy, a process developed a year and a half ago by the National Bureau of Standards for the production of electric-circuit modules on an automatic factory basis, has been modified slightly and is about to get into full scale production by the Electronics Div. of ACF Industries, Inc. ACF is calling their modules Compacs (component packages), and in their small plant located beneath a roller skating rink in Alexandria, Virginia, they expect to produce a half-million of these modules a month. However, this is only the beginning, for with the increasing demand by television manufacturers, ACF expects to put two new plants into full production by 1956, and hopes to be supplying one-third of the market.

The Compac, which carries about ten to twenty component parts, resembles the original Tinkertoy module, top, left. But, there are several distinct differences. The big change is that the small holes drilled in the printed circuit board to accommodate

the twelve vertical riser wires on the Tinkertoy module, have been replaced by one "square hole" to simplify assembly. Now, the bottom wafer is mounted flush against the bottom side of the printed circuit board and the twelve leads are simultaneously bent over and attached to the contacts of the printed circuit. The entire unit is then dip soldered. Also, all of the modules, whether for military or commercial use, are dipped in epoxy resin to meet military specifications.

The wafer is still made of steatite, is completely square ($\frac{7}{8}$ in.), and the notch depth has been reduced. The module is available with from 3 to 7 wafers. A wafer will hold from 1 to 4 resistors; 1 to 4 capacitors; and 1 or 2 inductors. A 7 or 9 pin tube socket is mounted on top. One ACF module with 7 wafers and a tube socket measures $1\frac{1}{2}$ in. from top to bottom.

ACF has improved the characteristics of most of the component element and has added several new ones. For example: a new glass capacitor with a range of 1 to 8,200 $\mu\mu$f at 600 v d-c; a new plastic film capacitor; and a new inductor with a range of 0.25 μh to 10.0 millihenry.

When the Project Tinkertoy method was announced (*Product Engineering*, Dec. 1953, page 134-143), it was geared strictly to the automatic factory, and meant a complete changeover from conventional methods of production. This, many companies were reluctant to do, because of the high cost. The Kaiser Electronics Div. of Willys Motors, Inc., has been operating a pilot line of the Tinkertoy method in a program sponsored by the Navy Bureau of Aeronautics as an industrial preparedness measure in production research. However, it has just been announced that the Aerovox Corp. of New Bedford, Massachusetts, has taken over this program, with most of the key personnel of Kaiser program being taken over by Aerovox.

To date, ACF has no military contract for their program, but none is needed to keep them busy. Four of the larger television manufacturers are working with ACF engineers in redesigning their sets for module production. One set will be announced within a month or two.

ACF says that their Compac modules will cost no more than the same unwired elements it replaces. The big savings will come in the product's assembly line. ACF feels that manufacturers should redesign for this method of production, and will advise anyone who is interested. They will not, however, reveal the secrets of their production line equipment other than that the line is more automatic than NBS tinkertoy plant.

New Reactor Jumps Power Output

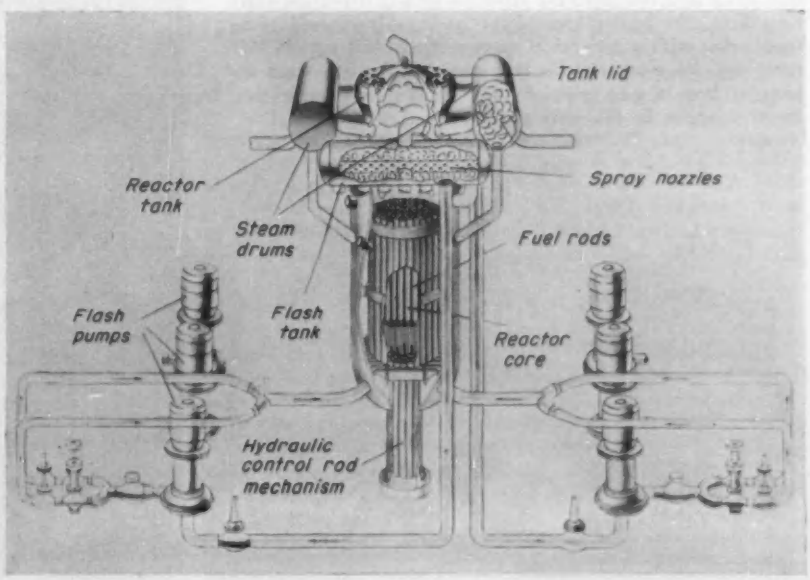
Less than a month after announcing a new type atomic power reactor with the reactor itself nested in the heat exchanger to save space (*Product Engineering*, June 1955, page 200), General Electric Co. just revealed the design of still another reactor which they claim as a "major advance toward the economic generation of electricity from atomic energy." Called the Dual-Cycle Boiling Reactor, its details are shown below.

A spokesman for G.E.'s Atomic Products Div. said that a reactor of this type will power the proposed full scale nuclear electric generating station for the Commonwealth Edison Co. near Chicago, Illinois. Plans set its generating capacity at 180,000 kw, the largest all-nuclear station yet scheduled. G. E. said that the new reactor will be able to produce several times as much power in a given size as the direct boiling reactor, and is a type expected to achieve generating costs which are competitive with ordinary steam power plants. The Commonwealth Edison project is being financed with private funds.

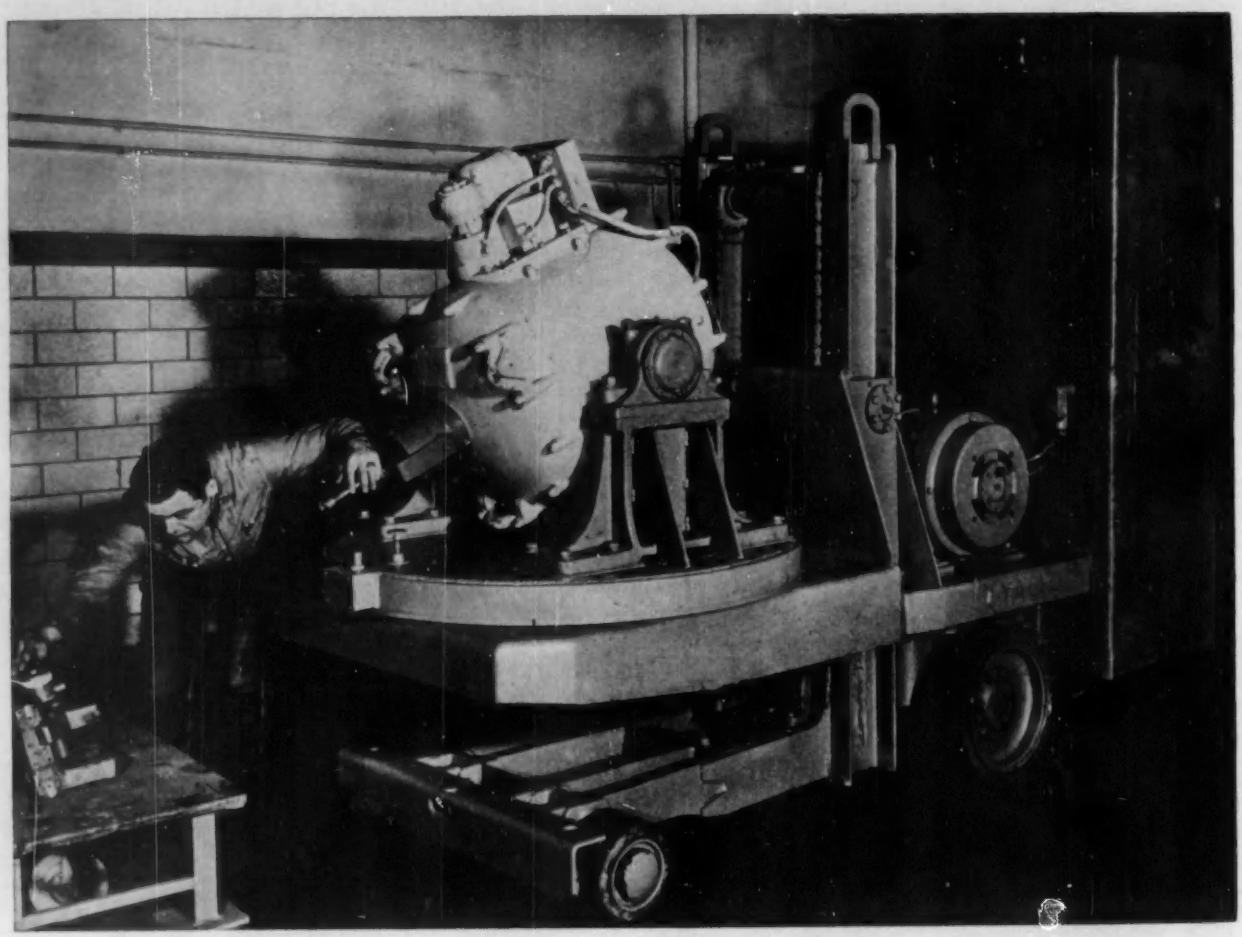
In operation, water circulates up from the bottom of the main pressure vessel, through the reactor core, and is converted into steam. The flash tank system was introduced into the reactor to control the steam formation by feeding cooler water into the entrance of the reactor as load demands increase. This maintains the balance of the chain reaction so that the reactor automatically delivers more power to supply any load increase. Also, steam is supplied to the turbine at two pressures: i.e., 600 psi from the reactor vessel, and 350 psi from the flash tanks.

Thus, by generating steam directly inside the reactor core, and without heat exchangers, the high pressures and temperatures used in liquid water cooled reactors will be eliminated. Conversely, a non-boiling reactor cooled by high temperature, high pressure water would have to operate at a pressure of about 2,000 psi in order to generate steam at 500 psi for the turbine.

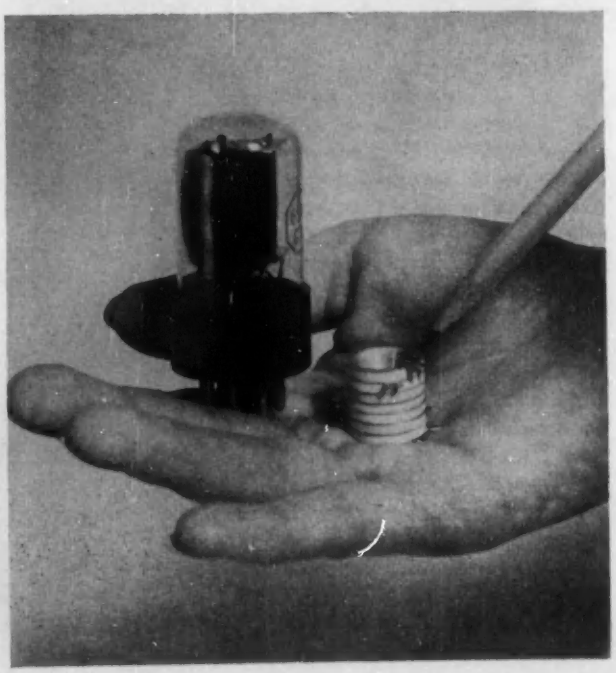
The reactor also has good thermal efficiency for a given reactor temperature; and a high degree of safety due to the boiling in the reactor.



THE NEWS IN PICTURES

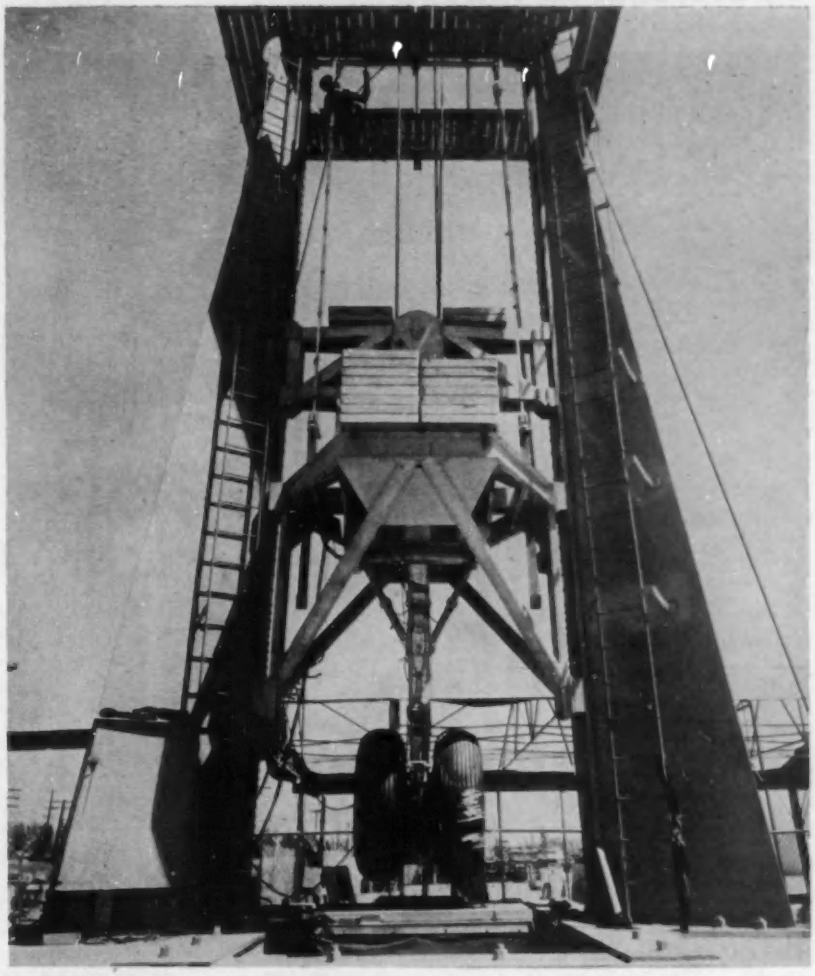


THE "ISOSCOPE" Babcock & Wilcox's new inspection device using radioactive Cobalt 60, is being "aimed" at a test specimen. Capable of looking through steel up to 7 in. thick, it requires only one-third the exposure time of a million volt x-ray unit. The lead sphere of the isoscope is encased in a steel jacket with a cylindrical rotor section built into it. By revolving the rotor 180 degrees, the radioactive source is brought from a safe position to a point in line with the coned opening in the steel jacket, allowing the radiation beam to escape. The total charge is 1008 curies of Cobalt 60, and is comprised of small disks stacked one on top of the other. Advantages of the unit over high voltage x-ray equipment: lower initial cost; less shielding needed for secondary radiation; greater mobility; simplified controls; pre-determined operating and maintenance costs.

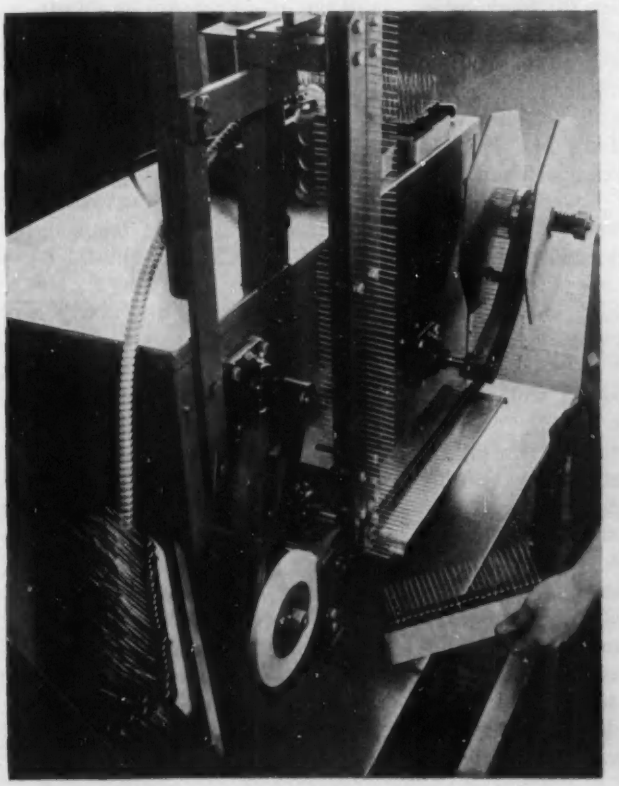


LESS THAN ONE-FOURTH THE SIZE of a comparable glass tube, this ceramic receiving tube was developed by Eitel-McCullough, Inc., San Bruno, Cal. for the Air Force for airborne and mobile electronic and communication systems. By replacing glass with ceramic, the new tube design will permit new circuit adaption, reduction in tube size, and will take several times as much physical shock as glass tubes. For instance, sockets are eliminated, and instead of the tube plugging in, it is soldered in its circuitry. Known as the CD-16, it is less than ¼ in. in height and diameter. The tube, plus its complete wiring, in printed circuit form, is smaller than one conventional receiving tube.

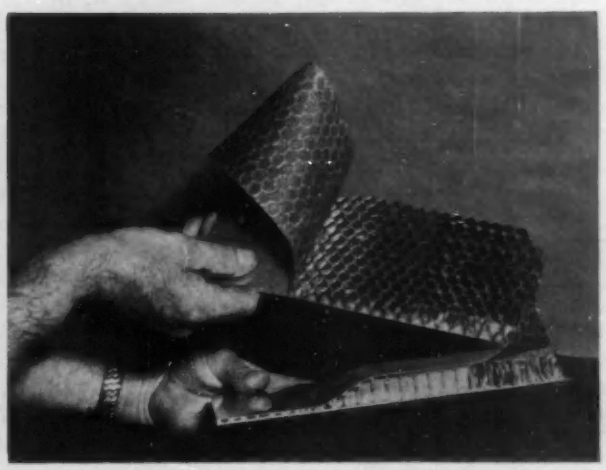
MAIN LANDING GEAR of a Constellation in the 40 ft. drop tower at Lockheed Aircraft's research department. The lead weights on the platform above the gear weigh about 25-tons, or half the weight of the plane in landing conditions. Using Baldwin-Lima-Hamilton strain gages, tests are made to determine the motions of the gear in space, and the forces applied to it during the landing period. The entire loading period is about one-tenth of a second. During the tests, the wheels are rotated backward to simulate the forward motion of the plane at the landing. Impact with the ground causes large drag loads in the fore and aft direction in the gear, in addition to vertical loads in stopping the moving weight.



BY INCORPORATING Minnesota Mining & Mfg. Company's scotch brand filament tape no. 898 into their production line, Allen-Bradley Co. can supply resistors and capacitors on expendable 9 and 12 in. reel holding from 1,000 to 2,500 units each. The small machine needs only a 1/20 hp motor to run a simple chain drive mechanism that operates the indexer and rewind wheel. Production is between 10 and 20 filled reels (more than 20,000 individual units) per hour. All the operator must do is maintain a supply of units, and renew the supply of tape when necessary. Shown from left to right are: sleeve-in-tray type packs for feeding the machine; white roll of filament tape; rubber buffing roller; the indexer which positions the units on the tape; and at far right the reel.



METAL BONDED PANELS made with a metal honeycomb center are being crushed vertically around the edges to form the flaps, inboard ailerons, and trailing edges of Boeing Aircraft's new "707" jet tanker-transport. It was found that the honeycomb edges could be crushed without loss of strength, into areas where the top and bottom of the sandwich are drawn together. Furthermore, the method was easily controllable, and gave fewer parts with less trouble with the manufacturing tolerances. Boeing has also developed a special saw and vibrating sander for machining contours into the honeycomb. Machining honeycomb with an electrode is also being investigated.



Heavy Press Program At Half-Way Mark

The recent dedication of 35,000 and 50,000 ton hydraulic forging presses at the Aluminum Company of America's Cleveland, Ohio works was significant in that it meant that the U. S. Air Force's Heavy Press program has reached its halfway mark. By the end of November of this year, all ten of the presses should be in operation. When complete, there will be two 50,000 ton and two 35,000 ton forging presses, and one 14,000 ton, two 12,000 ton, and three 8,000 ton extrusion presses. Overall cost of the program is estimated at $279-million. This amount includes the presses, facilities, and supporting costs, such as transportation and industry expansion. Alcoa will operate the new plant under a lease which returns to the Air Force 4 per cent of the company's gross sales from products made on the presses.

Two big advantages of the big presses are: larger forgings, and more complex forgings. Greater precision can be attained on the forgings, and the increased pressure can be used to get thin ribs and webs, and draft angles reduced almost to zero.

The Mesta 50,000 ton press has a die table 12 ft. by 26 ft., which is withdrawn only when the forging dies are changed. Parts are removed and ingots inserted between the dies by a manipulator moving on rails. The maximum press stroke is 6 ft., with a working stroke of one foot designed to operate at 30 cycles per hour. The press stands 50 ft. above and 36 ft. below the floor level.

The United Engineering & Foundry 35,000 ton press has a platen area of 24 ft. by 12 feet, corresponding to about 120 tons per sq. foot. The press will reach open-forging-press speeds of 10 ips idling, and 2½ ips under full pressure.

In the aircraft field, the new presses will be able to turn out: (1) wing beam carry-through fittings in one piece instead of the three to four assembled pieces formerly used; (2) landing gear bulkheads, particularly for large planes; (3) wing beams consisting of upper and lower caps integral with the webs; forgings can taper the section to conform to the tapering depth of the wing; and (4) reinforced skin panels; this is the closest approach to the concept of forging entire sections at one time.

The Air Force announced that Russia is known to have a 33,000 ton press which they took from Germany after World War II. A 55,000 ton press designed by the Germans but not built before the end of the war, is also believed to be in Russian hands.

In the foreground in the picture left is the 35,000 ton press, and in the background the 50,000 ton unit, all under one roof at Alcoa's Cleveland plant. Concrete caisson for the 50,000 ton press are sunk 78 ft. below floor level and rest on bedrock. Plant includes a die shop with 17 major die-sinking machines.

Machine Tool Show and Powerama in Chicago

From Sept. 6th to the 17th, Chicago will be host to just about any U. S. machine tool builder interested in displaying his products. At this time, the 1955 Machine Tool Show will be held at Chicago's International Amphitheatre with over 160 exhibitors taking part. Exhibitors will be confined entirely to American builders of machine tools, and exhibits will consist of machine tools only. No foreign builders will exhibit, and no foreign-built machine tools will be shown.

In conjunction with this show, the Production Engineering Show will be held on the Navy Pier. This show will be devoted to mechanisms, instruments, and equipment that contribute to greater production, and provides a place for the exhibit of accessories for which there will be no room at the Machine Tool Show. Shuttle buses will run to both shows from the downtown hotels, and shuttle buses will run between the two shows.

Running concurrently with these shows will be the Metalworking Machinery & Equipment Exposition at the Chicago Coliseum. Exhibitors are makers of production and metalworking machinery, specialty machines, and other equipment.

Starting August 31st and running through Sept. 25th, will be General Motors Powerama Show, which will display everything in the field of diesel power, including the heavy earthmoving equipment, plus the latest in aircraft power. This show will be adjacent to Soldiers Field on the lake front.

Coming Events

AUG. 15-AUG. 26

Massachusetts Institute of Technology, Cambridge 39, Mass. Special two-week summer program on Noise Reduction. This year's program will be directed to the man who has a noise problem. Topics will include: behavior of sound waves; decibels, sound pressure level, sound power level, and intensity level; quieting of engines; integrated noise control problems; and others. Contact: Summer Session Office, Room 7-103, Mass. Institute of Technology, Cambridge 39, Mass.

AUG. 22-23

"Electronic and Automatic Production", sponsored by the National Industrial Conference Board and the Stanford Research Institute, San Francisco, Calif. It will precede the annual Western Electronic Show and Convention scheduled there for the same week. Discussion will cover: Management considerations of capital and plant requirements; Production control and marketing; How automation may be expected to affect the electronics, machine tool and material handling industries; Quality control and personnel requirements; Factors influencing product design; and many others. For more information write to: National Conference Board, 247 Park Ave., N. Y., or the Stanford Research Institute, Palo Alto, Calif.

AUG. 24-26

Western Electronic Show and Convention, San Francisco, Calif. The show will be held at the Civic Auditorium, with Convention Headquarters at the Fairmont Hotel. For full particulars contact: Mal Mobley, Jr., WESCON, 344 N. La Brea Ave., Los Angeles 36, Calif.

SEPT. 6-17

National Machine Tool Show, the Production Engineering Show, and the Metalworking Machinery and Equipment Exposition, Chicago, Ill. Held simultaneously, the Machine Tool Show will be in the International Amphitheatre, the Production Engineering Show on the Navy Pier, and the Metalworking Machinery Exposition at the Chicago Coliseum. Shuttle busses will run from the Loop area to the shows, and between the shows. Exhibits at the Machine Tool Show will be confined strictly to machine tools. At the Production Engineering Show, some of the exhibits will be of electronic devices, air gauges, conveyors, brakes, clutches, and drive mechanisms, weighing equipment, lubricating systems and others.

Sept. 12-14

American Society of Mechanical Engineers' 1955 Western Conference on Applied Mechanics, at the U. S. Naval Postgraduate School, Monterey, Cal.

SEPT. 12-16

Instrument Society of America, Annual Instrument Conference and Exhibit, Shrine Exposition Hall and Shrine Auditorium, Los Angeles, Cal. Clinics will be held during the conference. For more information write to: Dr. Arnold O. Beckman, 3443 S. Hill St., Los Angeles, Cal.

SEPT. 14-16

Association for Computing Machinery, Annual Meeting at The Univ. of Pennsylvania, Philadelphia, Pa. Primary effort of the convention will be directed toward bringing the engineer and businesman together to discuss their problems and progress. A series of papers on Linear Programming, Logical and Machine Design, Numerical Analysis, and Business Applications. A series of luncheons and discussion groups is also planned by the association.

SEPT. 20-22

10th Annual Industrial Packaging & Materials Handling Exposition, at the Kingsbridge Armory, New York City, N. Y. The exposition will combine manufacturers exhibits with short course technical sessions in cooperation with New York Univ., and a National Championship competition for the outstanding achievement in specific packaging and handling applications.

OCT. 3-5

National Electronics Conference, Hotel Sherman, Chicago, Ill. The conference is sponsored by the: AIEE; Illinois Institute of Technology; IRE; Northwestern Univ., and the Univ. of Illinois. Participating are: Mich. State College; Purdue Univ., Univ. of Mich.; Univ. of Wisconsin; Radio-Electronics-Television Manufacturers Association; and the Society of Motion Pictures and Television Engineers.

OCT. 10-12

ASME's Lubrication Conference at the Antlers Hotel, Indianapolis, Ind.

OCT. 23-26

American Gear Manufacturers Association, semi-annual meeting at the Edgewater Beach Hotel, Chicago.

OCT. 24-25

Institute of Radio Engineers, Profesional Group on Electron Devices, First Annual Technical Meeting, Shoreham Hotel, Washington, D. C. About 1,000 engineers and scientists are expected to attend, with a large representation coming from government agencies. Subjects discussed will be: developments and applications of electron tubes and transistors in radio, television, business machines, and in military equipment.

OCT. 31-NOV. 1

The 1955 East Coast Conference on Aeronautical and Navigational Electronics, Lord Baltimore Hotel. Baltimore, Md. Held jointly by the Baltimore section of the IRE, and the IRE Professional Group on Aeronautical and Navigational Electronics. Industrial exhibits are planned. Those interested in submitting papers should contact: Mr. Norman Caplan, Bendix Radio Div., Bendix Aviation Corp., Towson 4, Md.

NOV. 14-18

Chicago Exposition of Power and Mechanical Engineering, under the auspices of the ASME, at the Chicago Coliseum, Chicago, Illinois. Held in conjunction with the 75th anniversary meeting. Among the highlights of the exposition will be series of papers by the Nuclear Engineering Division.

TO AMERICAN BUSINESS...

Thanks for Taming a Wild Horse

This is a message of appreciation to American industry. The occasion for the message is the completion of our eighth annual McGraw-Hill Survey of Business' Plans for New Plants and Equipment.

To a considerable degree, our appreciation is personal. It goes to the companies whose cooperation made our survey possible. Twice as many companies as in any previous McGraw-Hill annual survey carefully answered our questions about their plans to invest in new producing facilities. They gave a great deal of expensive time to the job. The cooperation of these companies, which employ nearly eight million workers, put the results of our survey on the firmest footing, in terms of coverage, it has ever had. For this cooperation we are most grateful.

But our appreciation is much more than personal. It extends in even greater degree to the kind of planning of investment in new plants and equipment which our survey revealed. The nature of this planning holds out promise that American industry is on the way toward bringing under control what historically has been one of the most upsetting forces in the American economy—the violent fluctuations in business capital investment. Progress in ironing out these fluctuations gives occasion for public gratitude.

A full report of the results of the eighth annual McGraw-Hill Survey of Business' Plans for New Plants and Equipment will be sent to anyone requesting it from the Department of Economics, McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, New York 36, N. Y.

Very Good Business News

The part of our surveys that attracts the widest interest is the news they give about immediate business prospects. And this year the news is very good. The survey results indicate that American business as a whole plans to invest $29.5 billion in new plants and equipment this year. That is 5% more than was invested last year, and a new high for any year.

Plans for the years 1956-1958 are also remarkably encouraging in terms of the amount of investment in prospect. American business reports that it is already planning to spend within 3% as much for new plants and equipment in 1956 as in 1955. In the past, the expenditures planned for future years have always been sharply lower than those planned for the current year. This is understandable enough. It is sometimes impossible to anticipate all the expenditures that will be necessary a year or more hence. Thus the fact that plans are already made

to spend almost as much in 1956 as this year is very good news about business prospects. The level of investment now planned for the years 1957 and 1958 is also remarkably high—far higher than ever reported for years that far ahead in previous McGraw-Hill surveys.

Taking the Long View

The fact that these plans exist is of immense constructive significance. It clearly indicates that more and more, and now in dramatic degree, American business is taking the long view in making its plans for capital investment. It is developing a program which, if successfully carried out, will go far toward eliminating the habitual, destructive surging and sagging of what is in effect the central power house of our economic system—capital investment by business. Upon the level of this investment depends not only the general state of our prosperity but our progress in raising the American standard of living with new products and new and better industrial processes.

Seven years ago, when we first asked industry to estimate its capital spending beyond the current year, only a small minority of companies could give us any estimates at all. This year, 87% of the cooperating companies—and it was a far larger number of companies—could comply with our request for estimates for the years 1956-1958.

It Pays to Bet on Growth

A number of developments help explain the increase in long-range planning of capital investment. One is the increasing technical complexity of American industry. It often takes longer, in this complicated age, to work out a successful installation of new plants and equipment. Another reason for long-range planning is American business management's increasing conviction that it pays to bet on the demonstrated capacity of the American economy to grow over the long pull. With this goes a corresponding determination not to let short-term business fluctuations upset individual company plans for growth through addition of new plants and equipment. An additional factor, and one of great and increasing importance, is the sense of public responsibility on the part of American business leaders who want to help prevent destructive swings in the levels of new investment.

It cannot be too strongly emphasized that there is still nothing automatic about the carrying out of these long-range plans for business spending. Actual expenditures are still governed in major degree by the general health of our economy. This is fully attested by the fact that the current business recovery has led to a substantial upward revision of the investment plans reported to us last fall when we made a preliminary check of plans for 1955. Either private economic excesses or a reversal of the recent improvements in federal tax policy could gravely upset realization of present plans. Fortunately, neither of these possibilities seems to be an immediate threat.

The very fact, however, that American business management has made these plans and will do its utmost to carry them out is a development of tremendous constructive importance for the American economy. It means that major efforts are being made to tame what historically has been an economic wild horse—the process of capital investment by business. Both for doing it, and for telling us about it in our annual surveys, we extend to American industry our sincere thanks.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments that are of particular concern to the business and professional community served by our industrial and technical publications.

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Donald C. McGraw

PRESIDENT

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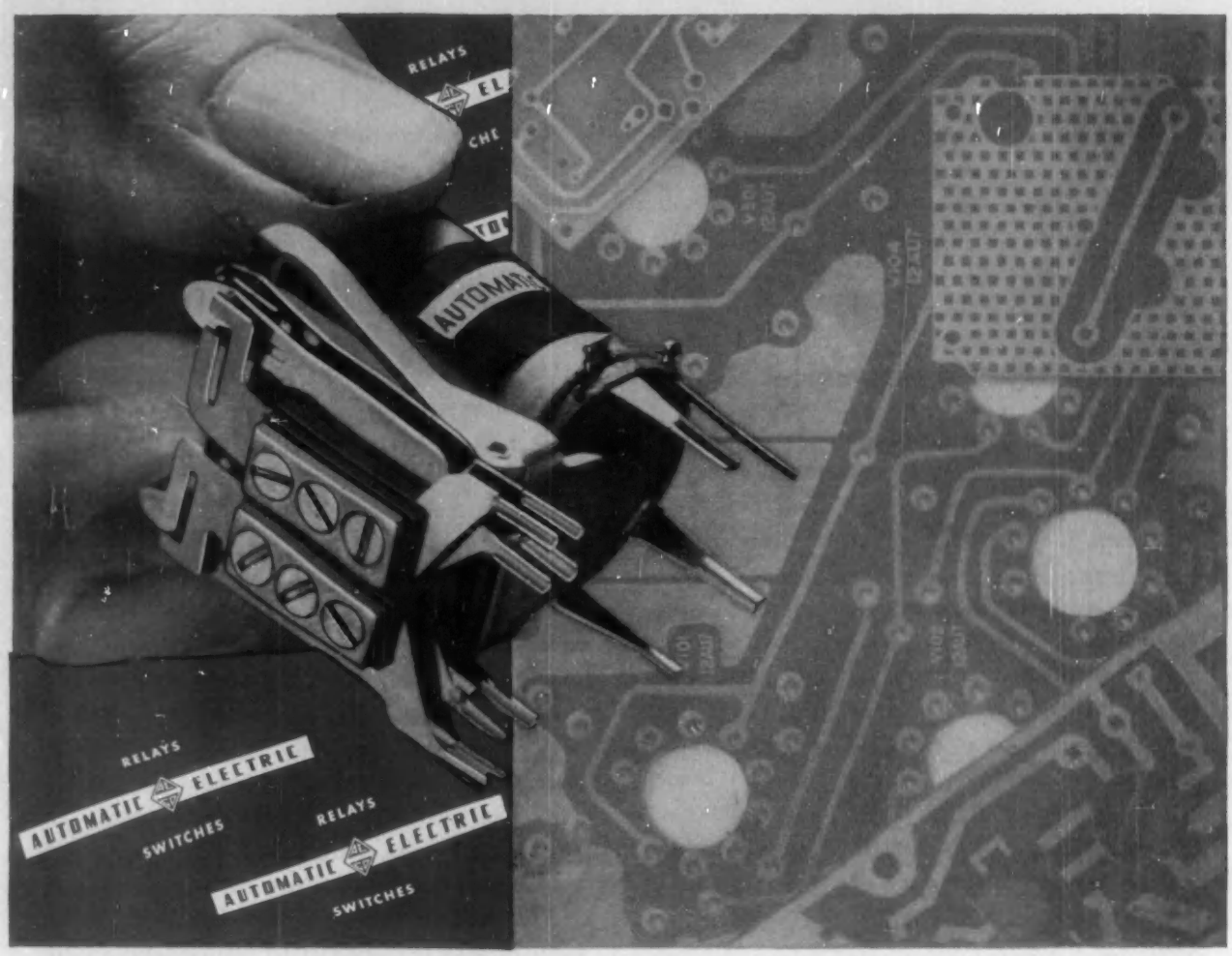

NOW!

dependable relays for printed circuits

Maybe you, too, have been awaiting availability of a *good* relay for direct insertion into printed circuits. Now Automatic Electric can solve your problem with a miniature relay that is just right.

120 million operations, without a single readjustment or relubrication! That's what you get from this rugged, improved Series SQD Relay, because it features a special *heavy-duty* bearing and bearing pin. Also a recess in the bearing plate retains an adequate supply of lubricant for long-term lubrication of the bearing pin.

Consider these additional advantages:

1. The sections of the terminals that insert into the printed circuit board are NOT brazed or welded into place, but are integral parts of the coil terminals and contact springs—thus preventing internal loss in conductivity or continuity.
2. Terminal design permits direct plug-in of the relay into a printed circuit board, ready to be secured in place with any acceptable soldering technique.

Usually the desired contact spring combination, or pile-up, is sufficiently large so that additional mounting (support) of the relay is not necessary.

SQD Miniature Printed Circuit Relays are available with many different contact spring arrangements, and for a multitude of applications. Springs can be made of phosphor-bronze, "Bronco" metal, or other special-purpose materials, as required.

Of course the long life, heavy-duty features of the improved SQD Relay can be had in the conventional type of plug-in relay, if regular sockets are preferred for use, whether in printed circuitry or other applications.

To get complete details, write: Automatic Electric Sales Corporation, 1033 West Van Buren St., Chicago 7, Illinois. *In Canada:* Automatic Electric (Canada) Ltd., Toronto. *Offices in principal cities.*

RELAYS SWITCHES

PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF

AUTOMATIC ELECTRIC

CHICAGO

Stress Equations For Strain Gage Rosettes

C. C. PERRY and H. R. LISSNER
Wayne University, Detroit, Mich.

Since the mathematics of converting from strains to stresses is rather tedious, special mechanical and electrical computers and several nomographs have been devised. But computers may be too expensive and the nomographs are complicated and only marginally better than longhand solutions—especially if principal stress problems occur only occasionally. Therefore, a table of equations has been prepared as a convenient reference for calculating significant stresses from measured strains.

IN STRESS ANALYZING PRODUCTS OR COMPONENTS, either the principal stresses or maximum shear stress may be of interest. Because stress itself cannot be measured directly, the usual process involves the measurement of strains from which the significant stresses are subsequently inferred through the laws of elasticity.

While there are several methods of measuring strains, the most versatile and widely used is the wire resistance strain gage. This gage can be cemented directly to the surface of the part in the region of high stress and, when connected with the proper instruments, will produce an electrical output proportional to the strain along the gage axis. To facilitate the simultaneous measurement of strains along several axes, the manufacturer produces rosettes which consist of from two to four wire grids oriented with respect to each other at specific angles.

There are three classes of circumstances commonly encountered by stress analysts: (1) uniaxial stress; (2) biaxial stress with directions of principal axes known; and (3) biaxial stress with direction of principal axes unknown.

The first class merely requires alignment of one conventional strain gage, and measurement of the strain along the one principal axis along which the stress exists. The observed strain can be multiplied by the modulus of elasticity of the material to calculate the maximum normal stress. The maximum shear stress will be equal to one-half the maximum normal stress and will act at an angle of 45 deg relative to the principal axis. This problem does not require a strain rosette.

The second class of applications is more complex. In a biaxial stress field the stress along either of the principal axes can be calculated from the following equation:

$$\sigma_x = \frac{E}{1-\mu^2}(\epsilon_x + \mu\epsilon_y)$$

From this it is evident that either principal stress is a function of both principal strains. This relationship necessitates the measurment of strains along both principal axes. While such measurement can be obtained using two individual gages, greater accuracy and convenience will result from the use of a two-gage rosette which has two independent strain sensitive elements mounted at right angles to one another. This composite gage is cemented in place with the axes of the elements coincident with the known principal axes of the part so that principal strains are observed directly. The accompanying table gives the equations for calculating all significant stresses from the resulting data.

The third and most general class of applications occurs when there is a biaxial stress field and the principal axes are unknown. A minimum of three strains must be measured, and therefore, a three-gage rosette (rectangular or delta) is required. The rosette can be cemented to the surface of the test piece with any convenient over-all orientation, since the equations in the table give not only the magnitudes of maximum and minimum principal stresses but will also allow calculation of the angle from any gage axis to the axis of the maximum normal stress. While selection of the particular rosette for any one application will depend upon a number of variables, such as the expected severity of stress gradient and the space available for the rosette, in general a delta rosette is preferable because of the slightly greater accuracy associated with the angular orientation of the grids. The grids in the rectangular rosette are at 45 deg intervals, as indicated in the table, while those in the delta rosette are at 60 deg. An exception to the above prefer-

(continued on page 209)

...in the use of ZINC DIE CASTINGS

A prime factor in the rapidly growing use of die castings has been the recognition of the process for what it has proved itself to be: The shortest distance between raw material and finished part. The automotive industry has been especially alert in taking advantage of this high speed production tool. 1955 models use eight times as much zinc die casting in front-end assemblies as the '54 models did.

Since this industry has been the top user of zinc die castings right along — taking more than half the total last year — the impressive swing to more zinc is significant. It definitely establishes the fact that zinc die castings are less costly to produce than those based on any other metal. Because of its low melting point, zinc can readily be cast in the most highly automatic machines. The more automatic and the more rapid the casting cycle, the greater the savings on costs. The smooth, as cast surface of zinc alloy castings is practically ready for plating. This gives zinc an advantage over all other die casting alloys for use as decorative objects and trim. In addition to all of the eye-catching chromium plated zinc die castings, the functional out-of-sight carburetor, fuel pump and windshield wiper housings continue to be zinc die cast at lowest cost.

The utilization of zinc die castings is also making rapid advances for important components in home appliances, hand tools, instruments, electrical equipment, business machines and innumerable other products which, were it not for zinc die castings, would be neither as attractive in appearance, as rugged, nor as low in cost.

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SALES OFFICE FOR PACIFIC COAST **NORTHWEST LEAD COMPANY** SEATTLE, WASHINGTON

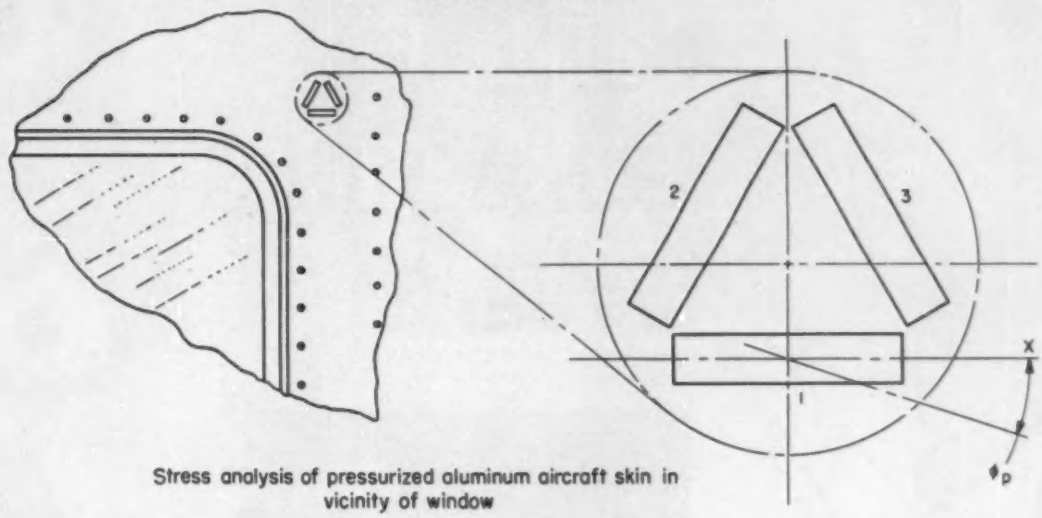
PRODUCT ENGINEERING - REFERENCE BOOK SHEET

Stress Equations (continued from page 207)

ence occurs when the principal stress directions are known approximately. For this condition, the rectangular rosette is preferable since the orthogonal gage can be initially aligned in the approximate directions of the principal stresses.

The T-delta rosette is identical to the delta rosette except that a fourth grid is built into the assembly at right angles to one of the other grids. The observed strains along the three axes of the gage forming a delta can be substituted into the conventional delta rosette equations in the table, and the output of the fourth gage used as a check on the accuracy, or, if desired, the outputs of all four grids can be substituted directly into the T-delta equations in the table to produce the magnitudes of the significant stresses and the angle to the maximum normal stress axis. *(continued on page 211)*

NUMERICAL EXAMPLE



Stress analysis of pressurized aluminum aircraft skin in vicinity of window

Measured strains from gages:

$\epsilon_1 = 1122 \times 10^{-6}$ in. per in.
$\epsilon_2 = -405 \times 10^{-6}$ in. per in.
$\epsilon_3 = 681 \times 10^{-6}$ in. per in.

NOTE:
$E = 10 \times 10^6$
$\mu = 0.33$

From the table

$$\sigma_{Max} = E\left[\frac{\epsilon_1+\epsilon_2+\epsilon_3}{3(1-\mu)} + \frac{1}{1+\mu}\sqrt{\left(\epsilon_1 - \frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}\right)^2 + \left(\frac{\epsilon_2-\epsilon_3}{\sqrt{3}}\right)^2}\right]$$

$$\sigma_{Max} = 10\times10^6\left[\frac{1122-405+681}{3(1-0.33)} + \frac{1}{1+0.33}\sqrt{\left(1122-\frac{1122-405+681}{3}\right)^2 + \left(\frac{-405-681}{\sqrt{3}}\right)^2}\right]\times10^{-6}$$

$\sigma_{Max} = 13{,}780$ psi (Tension)

$$\phi_p = \tfrac{1}{2}\,\text{Tan}^{-1}\left[\frac{\frac{1}{\sqrt{3}}(\epsilon_2-\epsilon_3)}{\epsilon_1 - \frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}}\right]$$

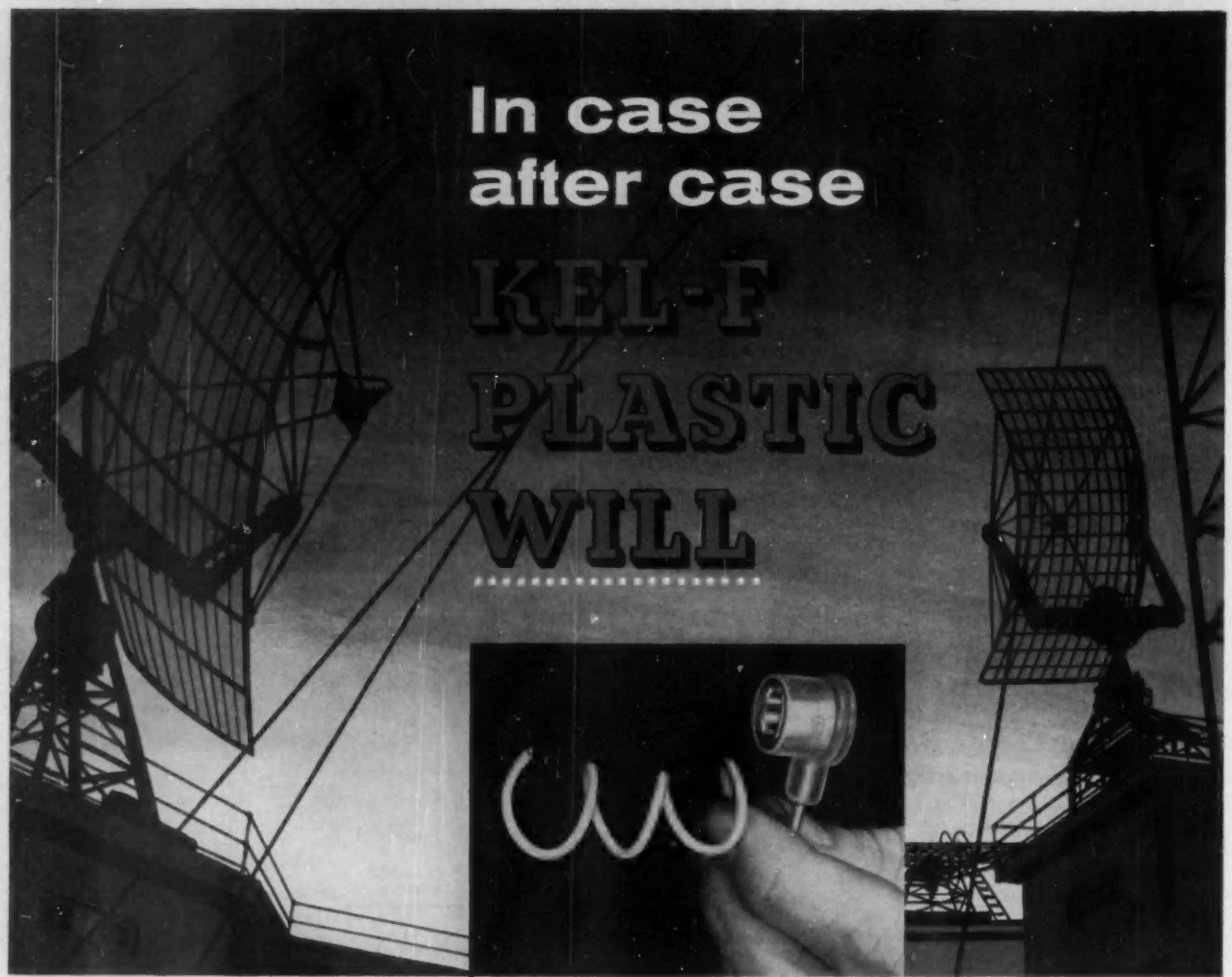
$$\phi_p = \tfrac{1}{2}\,\text{Tan}^{-1}\left[\frac{\frac{1}{\sqrt{3}}(-405-681)}{1122-\frac{1122-405+681}{3}}\right]$$

$\phi_p = -21°52'$

Angle from X-axis to max. principal stress axis
Negative angles - C.W.
Positive angles - CCW.

σ_{Min} and τ_{max} calculated similarly
$\sigma_{Min} = 140$ psi (Tension)
$\tau_{Max} = 6{,}820$ psi

When No Other Material Can Meet Your Electrical Requirements



New tube cap connector made of KEL-F Plastic insures high insulation resistance, and excellent dimensional stability over a wide temperature range (—320° to 390°F.) for critical installations.

KEL-F® PLASTIC *IS* UNIQUE. A polymer of trifluorochloroethylene, its molecular construction produces a combination of outstanding properties headed by excellent electrical characteristics, resistance to chemical attack and negligible deformation under load.

KEL-F Plastic is dense, tough, and readily moldable. It has an operational temperature range of approximately 710° F. (—320° F. to 390° F.) KEL-F Plastic is non-wettable, and moisture absorption is zero! In electrical applications it can be used structurally as well as dielectrically—particularly in the critical electronic applications encountered in sub-miniaturization, automation, servo-mechanisms, etc. And, as wire insulation, KEL-F Plastic offers outstanding abrasion resistance, so important in aircraft and other critical installations.

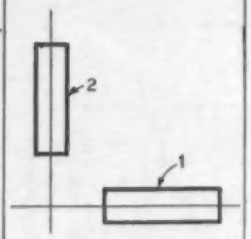
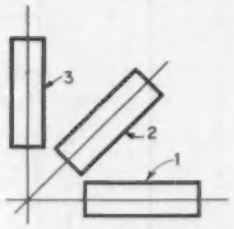
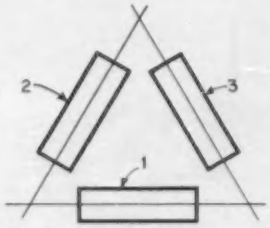
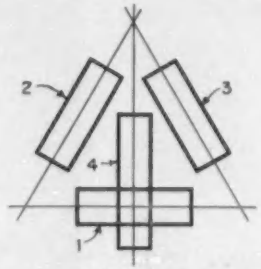
KEL-F Plastic is available as a molding compound, or in extruded film, sheeting, rods and tubing from independent fabricators. KEL-F Dispersions for bake-coating of metallic surfaces are also obtainable. The complete story of KEL-F Plastic should be in your "ready" file. Write for special bulletins.

THE M. W. KELLOGG COMPANY
Chemical Manufacturing Division, P. O. Box 469, Jersey City, N. J.
SUBSIDIARY OF PULLMAN INCORPORATED

®Registered trademark of The M. W. Kellogg Company's fluorocarbon polymers.

Stress Equations (continued from page 209)

RELATIONS BETWEEN STRAIN ROSETTE READINGS AND PRINCIPAL STRESSES

Rosette types → / Required solution ↓	 Two-gage	 Rectangular	 Delta	 T-Delta
Max normal stress, σ_{max}	$\frac{E}{1-\mu^2}(\epsilon_1 + \mu\epsilon_2)$	$\frac{E}{2}\left\{\frac{\epsilon_1+\epsilon_3}{1-\mu} + \frac{1}{1+\mu}\sqrt{(\epsilon_1-\epsilon_3)^2 + \left[2\epsilon_2 - (\epsilon_1+\epsilon_3)\right]^2}\right\}$	$E\left[\frac{\epsilon_1+\epsilon_2+\epsilon_3}{3(1-\mu)} + \frac{1}{1+\mu}\sqrt{\left(\epsilon_1 - \frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}\right)^2 + \left(\frac{\epsilon_2-\epsilon_3}{\sqrt{3}}\right)^2}\right]$	$\frac{E}{2}\left[\frac{\epsilon_1-\epsilon_4}{1-\mu} + \frac{1}{1+\mu}\sqrt{(\epsilon_1-\epsilon_4)^2 + \frac{4}{3}(\epsilon_2-\epsilon_3)^2}\right]$
Min normal stress, σ_{min}	$\frac{E}{1-\mu^2}(\epsilon_2 + \mu\epsilon_1)$	$\frac{E}{2}\left\{\frac{\epsilon_1+\epsilon_3}{1-\mu} - \frac{1}{1+\mu}\sqrt{(\epsilon_1-\epsilon_3)^2 + \left[2\epsilon_2 - (\epsilon_1+\epsilon_3)\right]^2}\right\}$	$E\left[\frac{\epsilon_1+\epsilon_2+\epsilon_3}{3(1-\mu)} - \frac{1}{1+\mu}\sqrt{\left(\epsilon_1 - \frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}\right)^2 + \left(\frac{\epsilon_2-\epsilon_3}{\sqrt{3}}\right)^2}\right]$	$\frac{E}{2}\left[\frac{\epsilon_1+\epsilon_4}{1-\mu} - \frac{1}{1+\mu}\sqrt{(\epsilon_1-\epsilon_4)^2 + \frac{4}{3}(\epsilon_2-\epsilon_3)^2}\right]$
Max shearing stress, τ_{max}	$\frac{E}{2(1+\mu)}(\epsilon_1 - \epsilon_2)$	$\frac{E}{2(1+\mu)}\sqrt{(\epsilon_1-\epsilon_3)^2 + \left[2\epsilon_2 - (\epsilon_1+\epsilon_3)\right]^2}$	$\frac{E}{1+\mu}\sqrt{\left(\epsilon_1 - \frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}\right)^2 + \left(\frac{\epsilon_2-\epsilon_3}{\sqrt{3}}\right)^2}$	$\frac{E}{2(1+\mu)}\sqrt{(\epsilon_1-\epsilon_4)^2 + \frac{4}{3}(\epsilon_2-\epsilon_3)^2}$
Angle from gage 1 axis to max normal stress axis, φ_p	0	$\frac{1}{2}\tan^{-1}\left[\frac{2\epsilon_2 - (\epsilon_1+\epsilon_3)}{\epsilon_1-\epsilon_3}\right]$	$\frac{1}{2}\tan^{-1}\left[\frac{\frac{1}{\sqrt{3}}(\epsilon_2-\epsilon_3)}{\epsilon_1 - \frac{\epsilon_1+\epsilon_2+\epsilon_3}{3}}\right]$	$\frac{1}{2}\tan^{-1}\left(\frac{2(\epsilon_2-\epsilon_3)}{\sqrt{3}(\epsilon_1-\epsilon_4)}\right)$

Ref. The Strain Gage Primer, C.C. Perry and H.R. Lissner, McGraw-Hill Book Co., 1955. $6.00

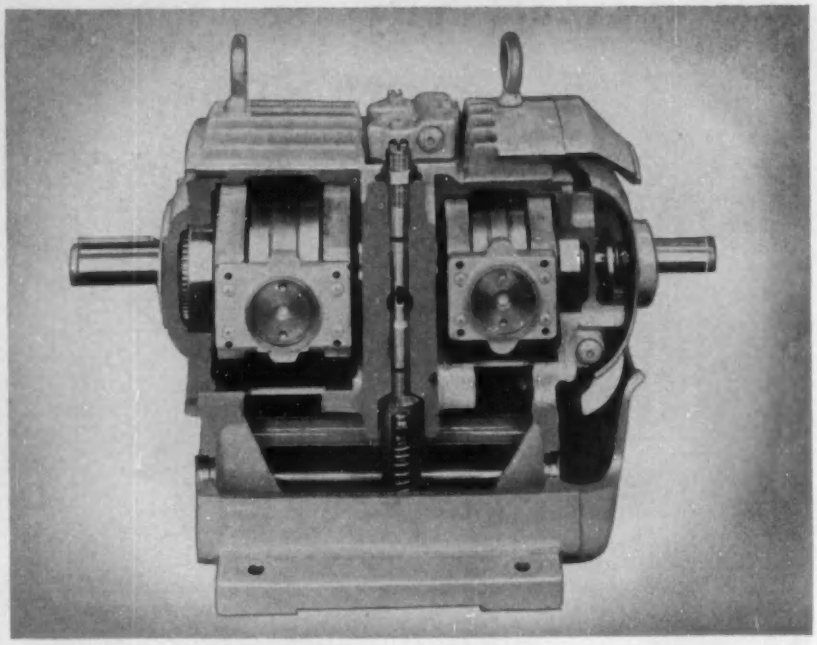
Hydraulic Transmission Delivers High Torque at Low Speeds

A hydraulic transmission that provides high torque in the low speed range is now available. Completely self-contained, this unit is reported to provide a smooth, infinitely variable speed drive, from full forward through zero to full reverse speed, without reversing the electric motor. Manual or remote controls may be used for speed change, and braking from any speed can be accomplished without stopping the electric motor.

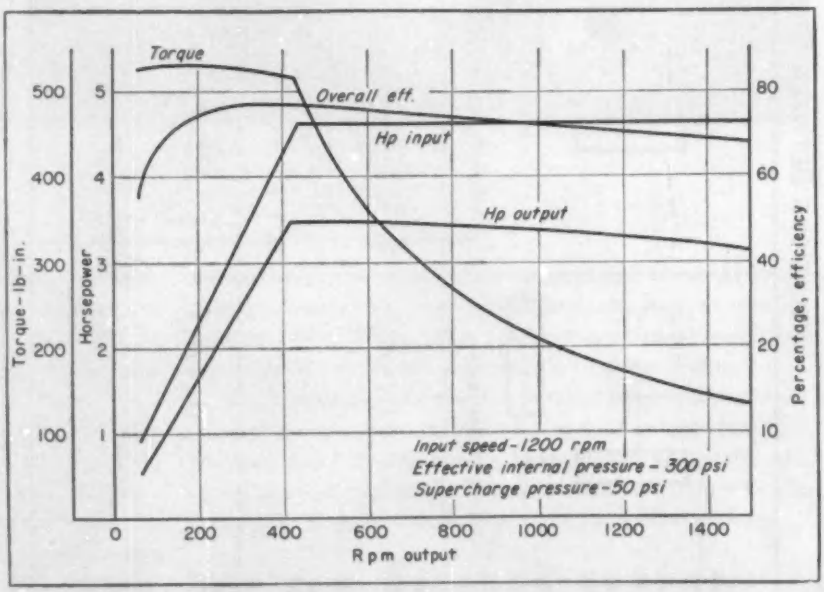
A variable displacement vane pump driven by a constant speed power source provides oil at an effective 300 psi to a variable displacement vane motor connected to the output shaft. With the vane motor set for full displacement, changes in the pump output will vary the motor speed at practically constant output torque. This constant torque output is provided up to a speed of 425 rpm. When full displacement of the pump has been set, maximum power is supplied to the vane motor. To increase the output speed further, the motor displacement setting is reduced, resulting in a corresponding reduction of output torque.

A small auxiliary internal gear pump draws power from the input shaft and supercharges the oil supply to the vane pump to approximately 50 psi. Cavitation is thereby reduced to a minimum. This 50 psi supply also may be used for auxiliary speed controls.

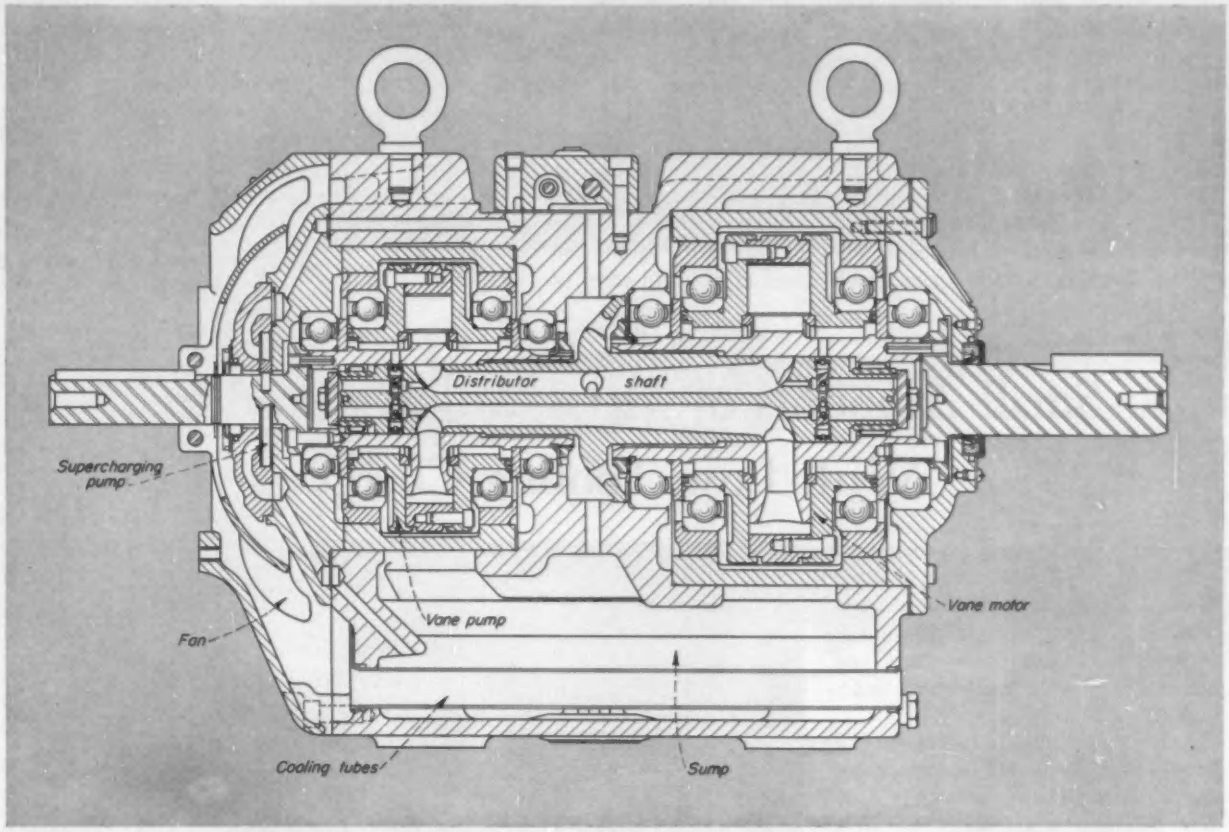
The pump housing is mounted in its own bearings whose center is offset from that of the rotor permitting the housing to rotate eccentrically with the rotor which considerably reduces the sliding action between vanes and cam ring. Changes in displacement of the pump are made by varying the amount and direction of this eccentricity on self-aligning ways. The hydraulic motor is similar in construction to the pump.

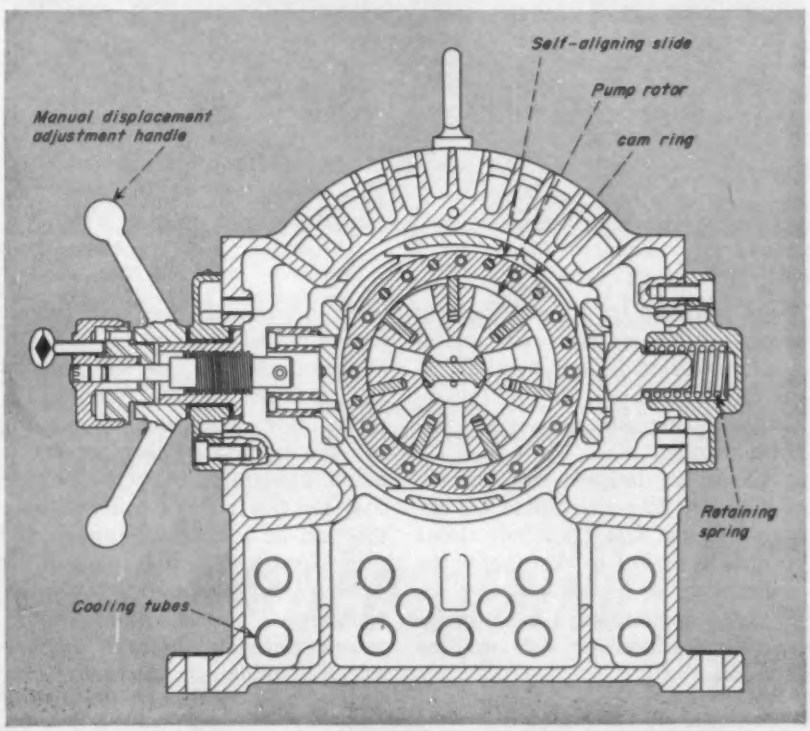


CUTAWAY VIEW OF HYDRAULIC TRANSMISSION, showing vane motor at left and vane pump at right. Supercharging gear pump and fan are also at right, mounted outside the transmission's vane pump.



HORSEPOWER OUTPUT INCREASES with speed until full displacement of pump is reached. Further increases in speed result in hyperbolic drop of torque.





SMALL GEAR PUMP (Above) at extreme left supplies supercharged oil through hydraulically actuated valve (top center) to distributor shaft. Vane pump at left raises pressure to 350 psi and supplies variable flow to motor at right.

ENTIRE PUMP HOUSING (Left) including cam ring may be shifted left and right, eccentric to rotor center, on self-aligning slides. Housing is free to rotate with rotor on its own bearings.

and both of these units are contained in a sturdy alloy cast iron housing.

Oil inlet and outlet ports are machined in a fixed distribution shaft running through the centers of both rotors. Radial holes from the vane spaces communicate with the inlet and outlet ports providing for an exchange of oil between pump and motor. In this manner a small, relatively quiet pump provides additional oil to the supercharger to make up for losses in the hydraulic circuit. Addi-

CONTINUED ON PAGE 214

tional ports in the distribution shaft pressurize the spaces under the vanes for hydraulic balancing.

Servicing of the transmission is reduced to a minimum by internal lubrication of all bearings and sliding surfaces. The low working pressure of 350 psi permits a longer operating life and the low starting torque of the pump permits the use of less expensive electric motor starters. Externally adjustable relief valves protect the transmission from shock or overloads.

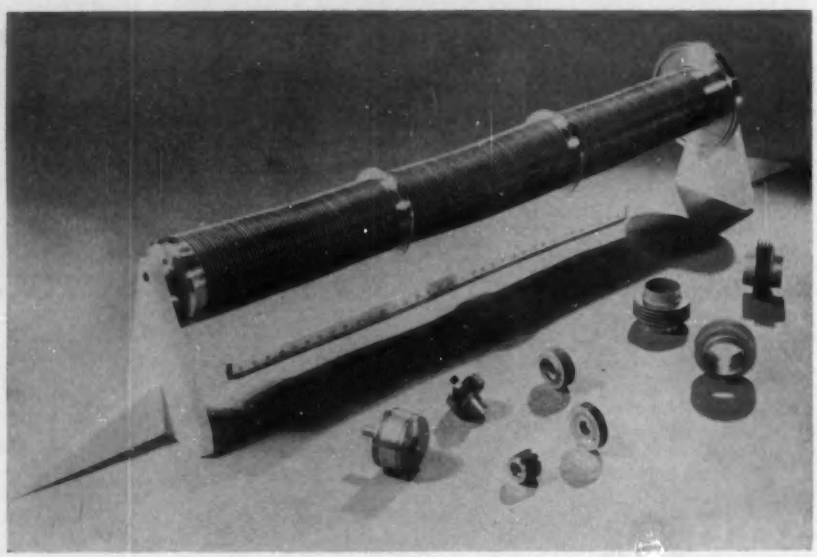
The German model upon which this design is based has been in use for over 20 years in a wide variety of industrial applications, so that the design has seen long service. In redesigning for American production the supercharger pump was added, the housing and bearings were strengthened and the design was adjusted to permit interchangeability of parts. New materials, including ductile iron of various tempers, are used.

Packaged units of transmission and electric drive motor are available, as well as optional servo controls for remote applications. The transmission will supply 3½ hp max output with a 5 hp electric drive motor.

Input speed, in either direction, is 1200 rpm in the presently available model of the new transmission, and the output speed range, also reversible, is zero to 1500 rpm. Maximum torque produced is 525 lb-in. Weight, less oil, is 314 lb and length (shaft end to shaft end) is 25¼ in. Gerotor May Corp., Baltimore 3, Md.

For more information—
Circle 1, inside back cover

Small Amounts of Metal Bellows Produced With Low Tooling Charges



These bellows consist of a series of contoured diaphragms, welded alternately at the inside and outside edges to form a stack. The special contour allows the diaphragms to nest and make contact with each other under high external pressure.

A ratio of extended to compressed length as high as 6:1 is practicable under favorable circumstances. Sudden transient loads, such as those caused by water hammer or surges created by high acceleration and deceleration, compress the diaphragms until they bottom. After the excessive load has passed, the bellows returns undamaged to its previous setting.

Stainless steel, Monel, Inconel and other metals that lend themselves to inert gas-shielded arc welding are suited to the fabrication of these bellows and their end connections. Corrosion factors and operating temperature usually determine the type of material to be used. Bellows can be supplied with neck, flange or special end connections to suit application.

Very often the customer's attaching members can be designed for welding, brazing or soldering directly to the end diaphragms, saving space and weight. The usual and most workable arrangement is for the manufacturers to supply a complete bellows assembly with connections attached.

Diaphragms are formed in a press or are produced by a metal spinning process. After accurate sizing of inside and outside diameters and checking for concentricity, they are assembled in appropriate fixtures for machine welding.

Bellows are designed with the use of empirical formulae, stress calculations and test data. It is not always possible to predict to close limits the performance of a bellows, and for difficult applications, adjustments based on performance data may be necessary.

Many factors must be considered when determining the best bellows for the job, among these are flexibility of stroke, effective area, size, internal and external pressure, service life, spring rate, operating temperature and vibration. Flexibility per convolution is controlled by metal thickness and, for this maker's bellows (since they can be controlled), contour and span. Span is defined as one half the difference between outside and inside diameters. As metal thickness increases, flexibility decreases rapidly—and the spring rate decreases along with it. Also, the greater the span of

CONTINUED ON PAGE 216

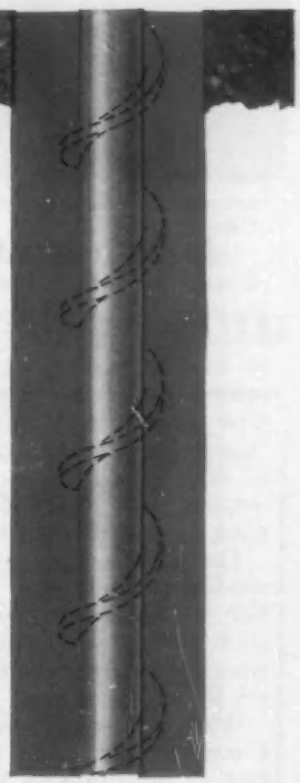
Kennametal tools working in a coal mine.

OSTUCO TUBING HELPED BOOST PRODUCTION AND REDUCE DRILLING COSTS

The Problem: Various mining augers originally used with Kennametal Tungsten carbide bits were frequently replaced due to bending and twisting—particularly in hard, fast drilling. This resulted in excessive downtime, and limited potential drilling life of the Kennametal bits . . . which are capable of drilling from 4,500 to 12,000 feet.

The Solution: New Kennametal augers, manufactured from OSTUCO Seamless Steel Tubing, last the life of several bits. These tubular augers have rigidity to stand the high pressure of fast, long-hole drilling, yet are light weight for easier handling underground. Lightness, rigidity and long wear are especially important in drilling holes of 100 feet depths during mining of anthracite coal and gypsum.

Discuss your particular problems with an OSTUCO Tubing Engineer. Then take advantage of OSTUCO's convenient *Single-Source* Service and fill all your tubing needs on one order. Write or call your nearest OSTUCO Sales Office, or write OSTUCO, Shelby, Ohio.



OSTUCO TUBING

SEAMLESS AND ELECTRIC WELDED STEEL TUBING
—Fabricating and Forging

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • **SHELBY, OHIO**
Birthplace of the Seamless Steel Tube Industry in America

SALES OFFICES: BIRMINGHAM • CHARLOTTE • CHICAGO (Oak Park)
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CANADA, RAILWAY & POWER ENGR. CORP., LTD.
EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY
117 Liberty Street, New York 6, New York

the convolution the greater the amount of flexibility.

Any number of convolutions can be added to increase flexibility of the bellows. For lengths that exceed the OD, either external or internal guidance is required to prevent squirming.

The size limits are given in the accompanying table.

It is difficult to give acceptable limits for pressure since 100 psi may be low for one bellows, and extremely high for another, depending on the flexibility desired, effective area and so on. Designs are on hand for pressures as high as 2500 psi and some test data has been gathered, but broad field experience is still forthcoming.

	Min, in.	Max, in.
OD	1¼	36
ID	¼	28
Span	⅝	4

Bellows of what this manufacturer calls standard sizes can be shipped in one week after receipt of order.

Service life can range from a few hundred to millions of cycles. Essentially, the design consideration for long life is to keep the stresses due to pressure and flexing well within the endurance limit of the metal. Belfab Corp., 11 Ramah Circle, Agawam, Mass.

For more information—
Circle 2, inside back cover

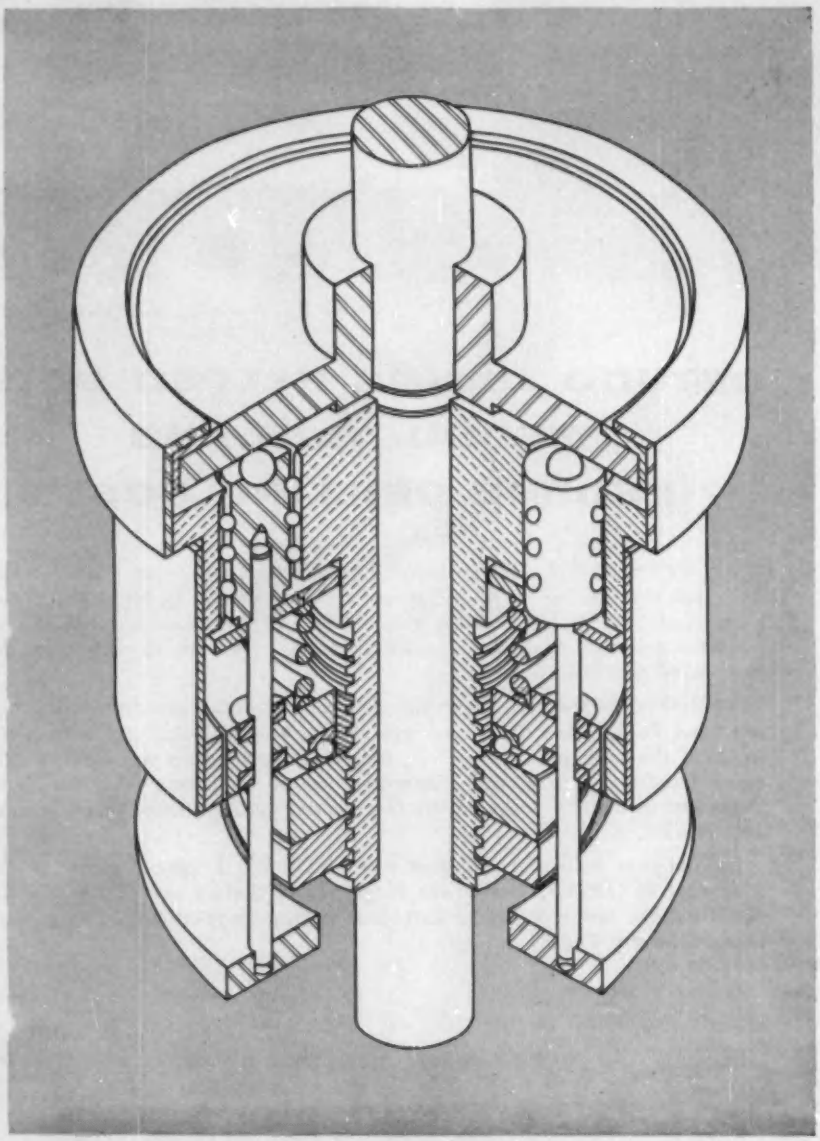
Limits Torque Without Backlash

A recently introduced device for controlling and fixing the maximum torque transmitted from a driving to a driven machine behaves like a conventional flexible coupling until it reaches its adjusted limit. It then permits a free-wheeling or slip effect between the driving and driven halves of the coupling.

Among the functional properties claimed with the developed free wheeling or slip effect are: 1) the ability to use the de-coupling action in tripping a safety or emergency switch, 2) the ability to use the repetitive detent action as a repetitive "hammer-blow" effect, 3) its ability to work as a bi-directional torque coupling with independent torque rating for each direction if required.

The new coupling is available in standard ratings from 24 to 100,000 lb-in. All models are adjustable from 50 to 150 per cent of their nominal ratings. Accuracy is said to be within ±5 per cent of settings.

When it is of value to "hammer" a coupled system past its "wedge-spot" in order to reach the free-running state, this coupling does this without introducing backlash or lag effects. It accomplishes this by applying its repetitive engagement and disengagement actions. On each passage from a disengagement to an engagement, it applies the sum of the driver's instanteous torque output and

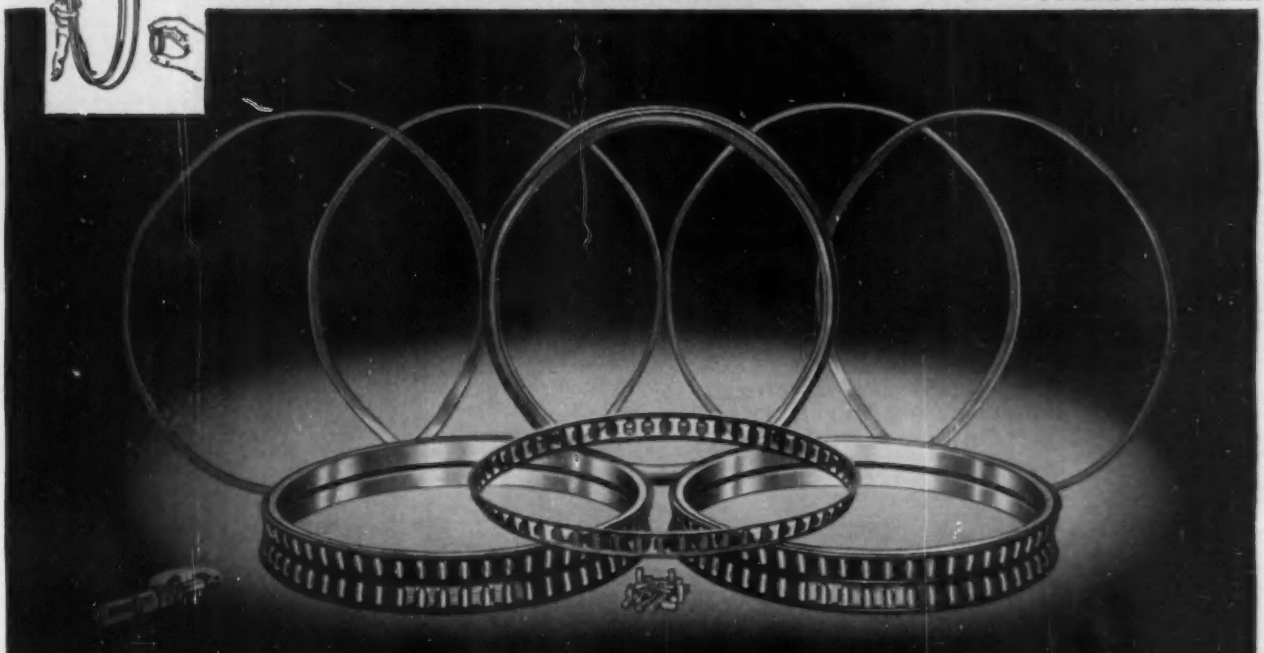


THIS FLEXIBLE COUPLING operates like a conventional unit until its set limit is reached. It is available in standard ratings from 24 to 100,000 lb-in.

CONTINUED ON PAGE 218

Contact KAYDON Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER



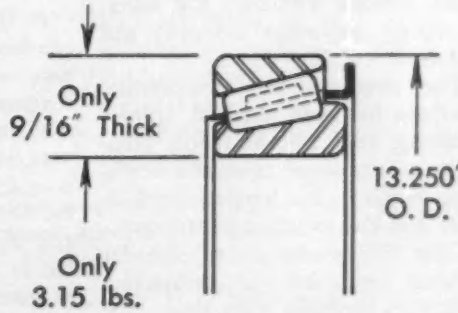
KAYDON single row, tapered roller bearings 12.125" x 13.250" x .718"
Total bearing weight: 3.15 lbs.

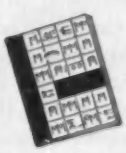
KAYDON creates world's THINNEST tapered roller bearings—REALI-SLIM as a wedding ring

Here's another first by **KAYDON** of Muskegon. We now offer the *thinnest* single row, tapered roller bearings ever made. Even a bride's modern wedding ring, made to proportionate size, would not be as thin or light in weight as one of these *Reali-Slim* bearings.

If you're faced with bearing problems, which involve conserving space and weight, consult **KAYDON** while your product design still is on the drawing board. Remember — for standard bearings or bearings of unusual design you can depend on **KAYDON** for the engineering skill and manufacturing facilities to do your job. It pays to contact **KAYDON** first!

Details of thin section, lightweight bearing shown above





Write for engineering catalog!

For complete data on capacity, seals, separators, standard and *Reali-Slim* "wedding ring" bearings, ask for catalog No. 54.

KAYDON types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-551

PRECISION BALL AND ROLLER BEARINGS

the flywheel inertia which is stored up in the driver during the coupling's low-load disengagement travel. On each passage from an engagement to a disengagement, it limits the applied hammer-blow to the adjusted torque limit, thus preserving the original protective effect.

Because the hammer-blow is thus limited and because it is derived from a repeated engagement and disengagement active pattern, it has the additional feature of exerting a cumulative rather than a "one-time" action. Techniflex Corp., Port Jervis, N. Y.

For more information—
Circle 3, inside back cover

Silicone Rubber Remains Flexible To 600 F

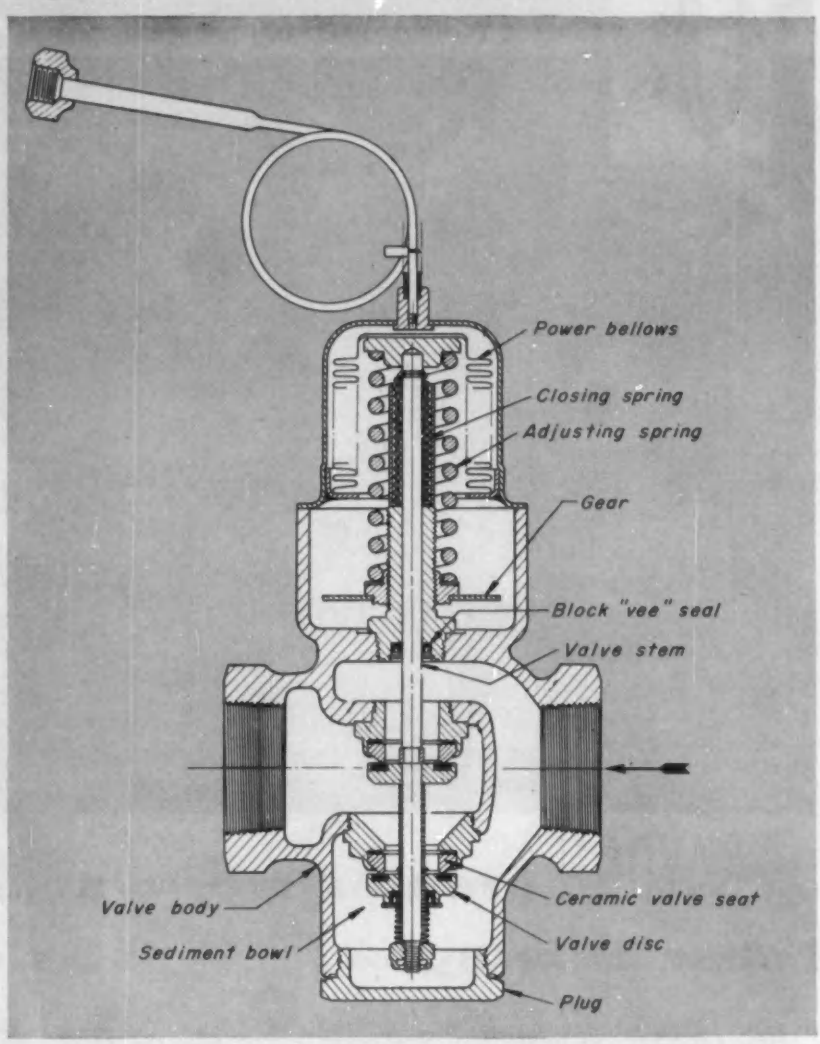
These silicone compounds are capable of remaining flexible for 150 hr or longer during continuous exposure up to the peak of the new temperature range, according to the manufacturer. Previously available types of silicone rubber became brittle in less than 24 hr at 600 F.

When used as kitchen oven door seals, Class 700 silicone rubber is said to seal in heat as well as cooking odors, prevent staining of range front surfaces, muffle door "clang", and is readily cleaned with soap and water. It retains rubber-like flexibility and usefulness.

The improved high temperature resistance has been obtained without sacrificing other silicone rubber properties, such as ozone, aging and weathering resistance, low temperature flexibility and low moisture absorption.

Class 700 stocks are suitable for molding, extrusion or calendering fabrication methods. One representative compound, designated SE-750A, is reported to be particularly suitable for the new hot air technique of curing extruded parts. General Electric Co., Waterford, N. Y.

For more information—
Circle 4, inside back cover



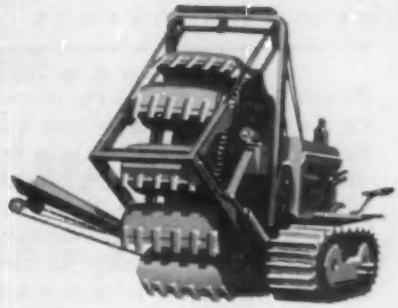
Pressure-Operated Water Regulating Valves

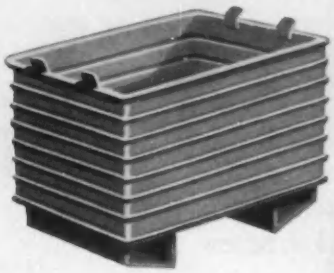
A type of water regulating valve extensively employed in the refrigeration industry is pressure actuated. It is operated by the discharge or high side pressure of the condensing unit with which is is employed. The valve is designed not only to start and stop the flow of water at the beginning and end of the running phase of cycle, but to automatically regulate the flow of water in response to the heat load imposed on the system. As heat loads vary, the valve varies the flow of water, increasing the flow as heat load increases and decreasing the flow of water when heat loads are reduced.

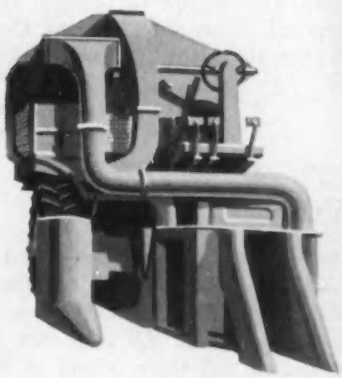
With the water valve in the closed position, normal for the off-phase of the machine's cycle, operation of the condensing unit at the start of the running phase of the cycle results in fast build-up of the high side or discharge pressure. Inasmuch as the actuating mechanism of the water valve is connected to the high pressure side of the system, usually at the discharge side of the compressor, pressure build-up depresses the valve bellows and moves the valve toward the open position.

At the valve's opening point, the rate of water flow is relatively small and high side pressure continues to climb. The valve moves further towards the full open position, and soon reaches a degree of opening at which

CONTINUED ON PAGE 220







MAKE IT WEIGH LESS

N·A·X

HIGH-TENSILE STEEL

MAKE IT LAST LONGER

You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel —it can be cold formed as readily into the most difficult shaped stamping.

When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel—long recognized specialists in flat-rolled steel products.

N-A-X Alloy Division

GREAT LAKES STEEL CORPORATION

Ecorse, Detroit 29, Mich. A Unit of

NATIONAL STEEL CORPORATION

the rate of water flow to the condensor is sufficient to dissipate heat from the condensing refrigerant at a rate equal to machine absorbing capacity. When this balance has been established, the condensing unit continues to operate at this discharge pressure. For this reason, the valve maintains constant discharge pressure during machine operation. What this pressure will be depends on the adjustment.

The new regulating valve can be used at either inlet or outlet locations. A capacity of 65 gpm at 50 psi is provided by 1 in. valve and 80 gpm at 50 psi by the larger 1¼ in. valve. Maximum water pressure capacity is 150 psi. The close-off pressure is approximately 5 psi below the opening point.

Neoprene valve discs are bonded in brass holders and close on ceramic seats. A sediment bowl at the bottom of valve makes it possible for foreign matter to be removed.

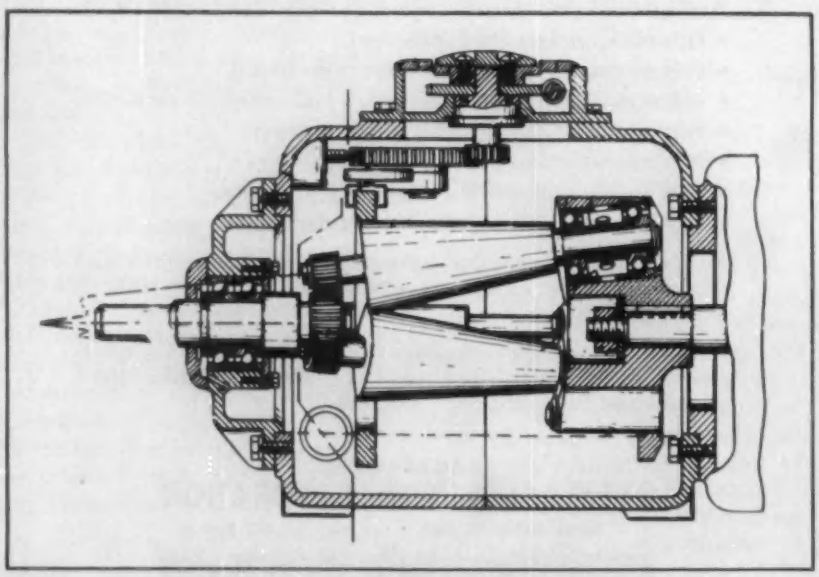
Removal of end plug allows discs and seats to be serviced without removing valve from the line or breaking connection. To adjust valve's opening point, a manual stem with reduction gear is provided. A-P Controls Corp., 2450 N. 32 St., Milwaukee 45, Wis.

For more information—
Circle 5, inside back cover

MECHANICAL COMPONENTS

Variable Speed Transmission

This transmission is designed to provide extreme accuracy of speed adjustment above and below input speed, as required on those applications where one portion of a machine must be accurately timed with respect to another, with small adjustments required due to variations such as the stretch of a web of material between wind-up and intermediate rolls. The unit's roller carrier or spider is driven by a motor (or input shaft if a transmission without motor is used). Three tapered rollers are supported in the carrier and are inclined at an angle equal to their taper so that the outer edge of the rollers is parallel to the central axis of the transmission. A control ring encircles the three rollers and traction pressure is developed between the rollers and the ring through the centrifugal force of the rollers as the carrier is rotated at motor speed. Bevel pinions fixed to the large end of the rollers engage a sun gear mounted on the output shaft.



The speed of the output shaft is equal to the speed of the input shaft plus a variable speed determined by the gear ratio and the diameter of the roller at which the encircling control ring makes contact. The ring position is set and maintained with what is described as great accuracy through the linkage shown in the drawing.

The new speed corrector can be obtained with a variety of special controls, remote mechanical, electrical, pneumatic, or hydraulic, to provide automatic control. Graham Transmissions, Inc., Menomonee Falls, Wis.

For more information—
Circle 7, inside back cover

External Wrenching Socket Screw

External wrenching, with the standard 12-point socket wrench, and increased wrenching area in this screw is said to result in greater wrenching torque. Also, no special hexagon key is required. Ferry Cap & Screw Co., 2151 Scranton Road, Cleveland 13, Ohio.

For more information—
Circle 6, inside back cover

Radial Bearings

In a line of radial bearings ⅛ to 1½ in. dia, both stud and bore types are available, with a wide choice of race and stud materials. All steel used is heat treated and there is said to be a minimum of radial and axial play. Grant Pulley & Hardware Corp., 31-85 Whitestone Pkwy., Flushing 54, N. Y.

For more information—
Circle 8, inside back cover

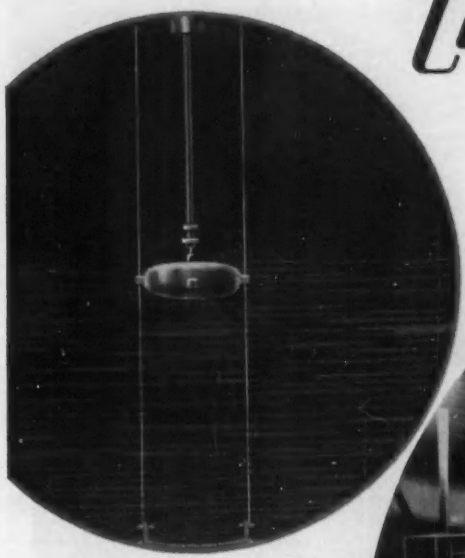
Torque-Tube Ball Bearings

These bearings are said to incorporate the first successful application of shields to an extremely thin section, torque-tube type bearing. They are equipped with non-metallic close clearance shields positively attached to the outer ring by a special method. No further sealing is needed except in

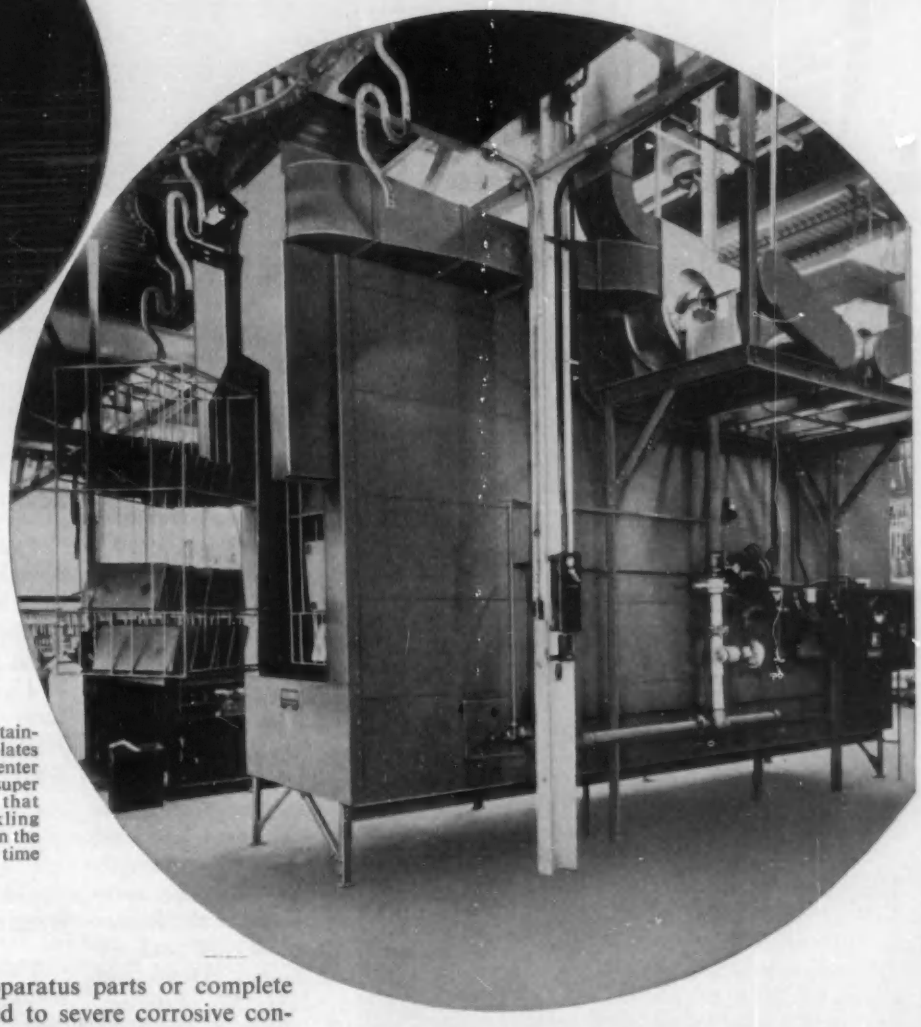
CONTINUED ON PAGE 222

In Small Parts or Large...

Carpenter Stainless No. 20 Controls STRONG Corrodents



SMALL—This diagram shows float and attached steel indicator strip of an automatic gauge used in sulphuric acid storage tanks. These parts are made from Carpenter Stainless No. 20 and No. 20Cb for longer life.



LARGE—Carpenter Stainless No. 20Cb sheet, plates and tubing, and Carpenter No. 20 bars provide super corrosion resistance that keeps huge acid-pickling machines like this one on the job, saves maintenance time and expense.

Wherever you have small apparatus parts or complete large-scale equipment subjected to severe corrosive conditions, you can build extra service life into them with Carpenter Stainless No. 20 and No. 20Cb.

This super stainless alloy is highly resistant to H_2SO_4 concentrations or solutions, as well as a long list of other strong corrodents. So build with Carpenter Stainless No. 20 and No. 20Cb for greater freedom from corrosion troubles, extended equipment life, less down-time for replacements, and greatly reduced corrosion control costs.

This time-saving, cost-cutting super corrosion-resistant Carpenter stainless alloy is available in the form of No. 20Cb tubing, pipe, sheet and plate, as well as No. 20 bar, wire, strip, and billets. Ask your nearest Carpenter distributor or sales office for assistance on your corrosion problems . . . and a copy of the NEW Carpenter Stainless No. 20 and No. 20Cb handbook.

MEMBER

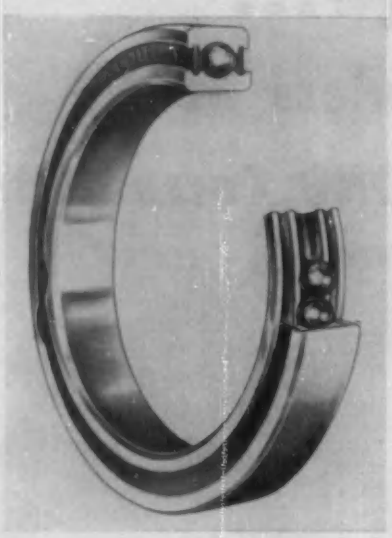
The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept., The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

more than corrosion resistance

Stainless Tubing & Pipe



extreme cases. All exposed surfaces are cadmium plated, and full faces are provided on both inner and outer rings.

Bearings in the new series are available in a full range of bore sizes from 0.6250 to 2.3125 in. They have a constant inner ring width of 0.281 in. Outer ring width is 0.250 in. and labyrinth seal. Fafnir Bearing Co., New Britain, Conn.

For more information—
Circle 9, inside back cover

Rectangular Sealing Rings

These rings are not laminated. They are one homogeneous piece. Cross-sectional tolerances can be held to ±0.004 in.

Diametrical tolerances held in most cases are ±0.005 in. from ¼ up to 3½ in. OD, and ±0.008 in. from 3½ to approximately 8½ in. OD. These seals are available in materials meeting military, AMS, and commercial specifications. Goshen Rubber Co., Inc., Goshen, Ind.

For more information—
Circle 10, inside back cover

Two-Bolt Flanged Ball Bearing

This bearing is available in shaft sizes from ½ to 2⅞ in. This two-bolt flange unit is zone hardened, self aligning and has a locking pin and dimple and labyrinth seal. Stephens-Adamson Mfg. Co., Aurora, Ill.

For more information—
Circle 11, inside back cover

Black Nylon Screws and Nuts

These fastenings are said to be usable at temperatures as high as 250 F. Sizes 6-32, 8-32 and 10-32 are available from stock. Weckesser Co., 5261 North Avondale Avenue, Chicago 30, Illinois.

For more information—
Circle 12, inside back cover

Miniature Screws From Stock

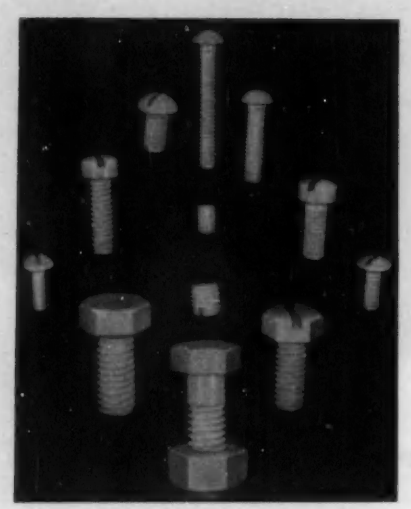
Imported miniature screws are now being carried in stock in a complete range of sizes for the first time in the United States. They are available for immediate delivery. Manufactured in Switzerland, the 0-80 and 1-72 screws range in size from 1/16 to ¾ in., in length increments of 1/64 in. They are available in steel and brass, in the following head styles: round, flat, oval, fillister, truss and binder. Heads and Threads, Inc., 2816 W. Peterson, Chicago 45, Ill.

For more information—
Circle 13, inside back cover

Nylon Machine Screws

Present inventories of these all-nylon fastenings include many popular sizes of machine screws in various colors, with additional items to be added. Said to withstand heat up to 450 F, these fastenings are unaffected by commercial solvents, alcohols, gasoline, oils and boiling 40 per cent caustic soda. Anti-Corrosive Metal Products Co., Inc., 1247 River Road, Castleton-on-Hudson, N. Y.

For more information—
Circle 14, inside back cover



Nylon Fastenings

These fasteners are self-locking, noncorrosive and insulating, and although they weigh, it is claimed, less than one-half as much as aluminum fasteners, they have tensile strengths up to 15,700 psi and can withstand continuous heat up to 300 F. Nylogrip Products, 449 Watertown St., Newton 58, Mass.

For more information—
Circle 15, inside back cover

Rotary Hydraulic Jack

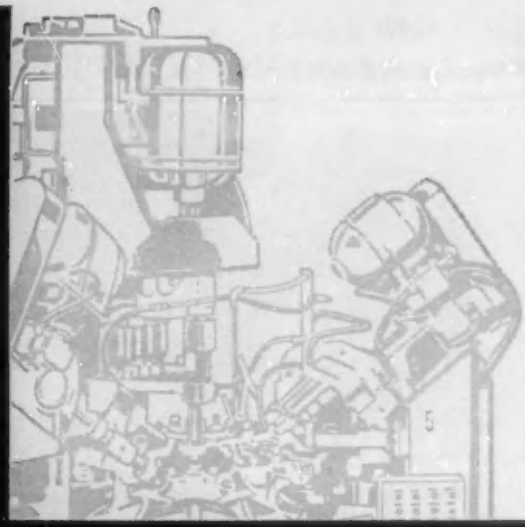
This device can provide torque for revolving, opening, closing, lifting, pushing and pulling by means of reciprocating rotary power. It consists of a cylindrical housing with end caps in which is mounted a rotating shaft with an attached vane. Hydraulic oil up to 1000 psi or lubricated air under pressure moves the vane, the complete rotation of which is limited by a stationary inside stop which allows a 300 deg movement of the shaft in either direction.

Speed of the shaft is determined by the capacity of the fluid pressure source, usually a vane or gear pump. Magnitude of torque depends on the

CONTINUED ON PAGE 224

LIKE SPECTACULAR COST CUTTING MACHINERY . . . .

that consolidates production operations in a single machine to speed up production and eliminate wasteful handling



CMP *cold rolled strip steel...*

can help step up your production rate

By working to restricted specifications for size, physical characteristics and finish, realized through precision cold rolling and heat treating processes, CMP can help in many ways to step up the production of parts made from flat rolled steel.

In many cases, "working qualities" can be so improved that machine speeds can be stepped up as much as 25%.

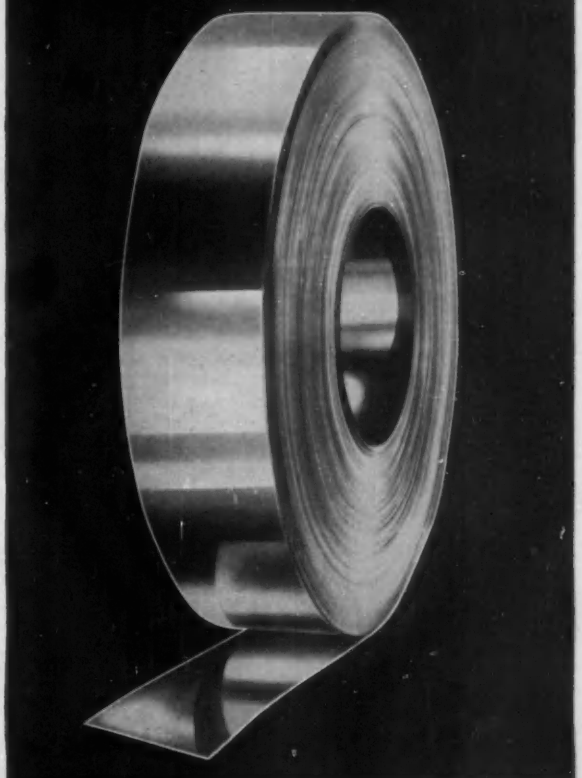
Frequently, qualities can be developed which permit simplification of tooling.

In some instances, restricted specifications may be developed which completely eliminate operations.

Where precision fitting is encountered, dimensional accuracy can be developed to greatly speed assembly and eliminate rejections.

In all cases, users enjoy the usual time-saving advantages of CMP's customary precision gauge and width tolerances . . . more footage per coil . . . fewer production shutdowns for coil replacement on automatic-feed operations . . . longer tool life.

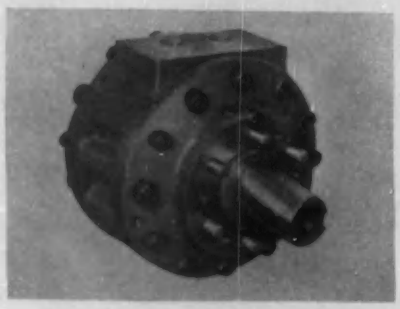
CMP's extensive experience in development of steel specifications for more efficient and economical production is always at your service.



the Cold Metal Products co.
GENERAL OFFICES: YOUNGSTOWN 1, OHIO
PLANTS: YOUNGSTOWN, OHIO AND INDIANAPOLIS, INDIANA
OFFICES: SALES Chicago • St. Louis • Los Angeles • San Francisco
New York • Cleveland • Detroit • Indianapolis

CMP WHERE YOU CAN GET SPECIFIC SPECS. FOR SPECIFIC JOBS

LOW CARBON	STAINLESS
HIGH CARBON	ALLOY
Annealed or Tempered	ELECTRO ZINC COATED



pressure exerted on the vane, which in the present-size unit is 10,000 lb-in. at 1000 psi. The unit can be face-mounted, or, by addition of a bracket, flange or foot-mounted. American Engineering Co., Aramingo Ave. and Cumberland St., Philadelphia 25, Pa.

For more information—
Circle 16, inside back cover

Fully Sealed Casters

These heavy-duty casters are sealed to prevent loss of lubricant and entry of foreign matter. A baffle ring protects swivel bearings from dirt and water. A grease retainer prevents swivel lubricant loss through vertical leakage. A wheel bearing seal keeps foreign matter outside, grease inside. Bassick Co., Bridgeport 2, Conn.

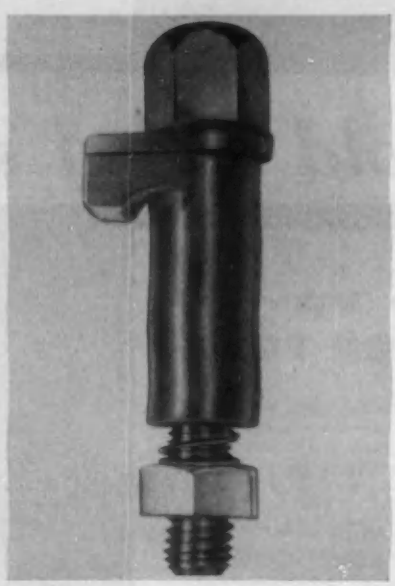
For more information—
Circle 17, inside back cover

Rotary Index Table

A 13-in dia. rotary index table is designed specifically for use where high accuracy in automatic feeding of work to tools is required. It can maintain repeat accuracies as close as 0.0005 in.

A cam movement is said to assure a positively locked table top at all times. The table top is equipped with hardened and ground steel dowel pins which are engaged by hardened tool steel pawls. The table top rotates on hand-scraped surfaces of the base housing. The unit is available in three styles: one for fixed indexing of four stations; one adjustable for indexing either six or twelve stations; and one adjustable for six, nine or 18 stations. Bellows Co., Akron 9, Ohio.

For more information—
Circle 18, inside back cover



Swing Clamp Assembly

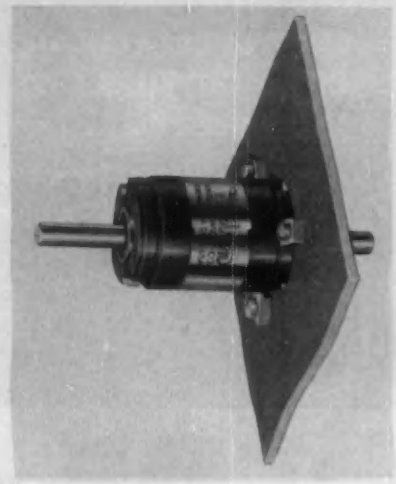
This clamp is available in a variety of sizes for close-quarter applications. Shank is spring-loaded, permitting assembly to swing out of the way either right or left. The forged heat treated steel body is mounted by simply drilling and tapping a hole. Jergens Tool Specialty Co., 712 E. 163 St., Cleveland, Ohio.

For more information—
Circle 19, inside back cover

Miniature Speed Reducers

These prefabricated reducers come in 448 different ratios—from 1:1 to 531,441:1. They may be either clamp-mounted by using the groove and a clamp assembly similar to the one shown, or end-mounted, using four tapped mounting holes.

These reducers have a nominal 1/40 hp rating. Their hobbed spur gears



are hardened. Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.

For more information—
Circle 20, inside back cover

Synthetic Fabric Conveyor Belts

Two new high tension conveyor belts constructed with synthetic fabrics have been announced. These new belts have working tension ratings up to 110 psi per ply. They are available with fabrics of either all rayon or chemically treated cotton warp with nylon filler. Boston Woven Hose & Rubber Co., P.O. Box 1071, Boston 3, Massachusetts.

For more information—
Circle 21, inside back cover

Miniature Vibration Isolator

This vibration mount's internal construction permits loading in any mounting position, even horizontal and inverted. It consists of seven principal parts. Two conical steel springs support the load; a split nylon washer between two steel washers provides vertical and lateral friction damping; two molded nylon spring seats also serve as top and bottom snubbing washers.

Low transmissibility of the new isolator at the resonant frequency is said to be afforded by the mount's effective friction damping properties. As a re-

CONTINUED ON PAGE 226

A Primer of Gas Turbine Engines

What is the man above holding?

He is holding a Solar "Mars" gas turbine engine. Its power output runs to 50 hp, but it weighs less than 100 lb and is smaller than a two-foot cube. It achieves this remarkable power-to-size ratio by running at a high speed: the shaft in this engine turns at 40,000 rpm!

Where are gas turbine engines being used?

Gas turbines today are finding an increasing variety of uses: in boats, where compactness is important; in airplanes, where light weight is essential; in remote pumping stations, where portability counts; in electric power plants, where reliability must be assured.

What advantages do small gas turbines offer?

Gas turbines are extremely light and compact; they permit smaller space envelopes and easy transportation, so important in such applications as portable fire pumps and airborne generator sets (photo above). Gas turbines are simple and rugged, with low maintenance cost. They need no cooling system and will operate on a variety of fuels. Low initial cost is anticipated, when gas turbines reach volume production.

What gas turbines are made by Solar?

Today in addition to the 50 hp Mars gas turbine, Solar is producing the 500 hp Jupiter gas turbine (photo above). Its weight installed is under 900 lb—less than one fourth that of a comparable diesel engine!

Mars engines have been adapted to many applications such as fire pumps, starter carts, and welding equipment, and they are in volume production for auxiliary generator sets used on the Douglas C-124C and Lockheed C-121C. Both constant speed Jupiter engines for generator sets and variable speed engines for ship propulsion have been built for the U.S. Navy.

Solar gas turbines are not yet generally available as all current production is going into military uses. Field testing of commercial applications is underway and production for civilian use is anticipated in the near future. Further information is available on request.

SOLAR AIRCRAFT COMPANY — SAN DIEGO, DES MOINES

DESIGNERS, DEVELOPERS AND MANUFACTURERS OF METAL ALLOY PRODUCTS

This is What Solar Offers You

When heat, corrosion or difficult specifications are problems, Solar can help you solve them. Solar specializes in the manufacture of precision products from alloys and special metals for severe service. Solar's experience since 1927 is unduplicated in this field.

SPECIAL PRODUCTS

Gas Turbines. *Solar "Mars" 50 hp engines for auxiliary generator sets, ground carts, portable fire pumps; Solar "Jupiter" 500 hp engines in variable and constant speed models.*

Bellows. *"Sola-Flex"® bellows and expansion joints in many designs from ½ in up to the world's largest, 28 ft in diameter.*

Controls. *Complete control systems utilizing the new Solar "Microjet"® principle for control of gas turbines, jet engines and pneumatic devices.*

CONTRACT PRODUCTION

Current orders include aircraft engine and airframe parts, pneumatic ducting, atomic energy components. Customers include the finest aircraft and industrial companies in the U.S. and Europe.

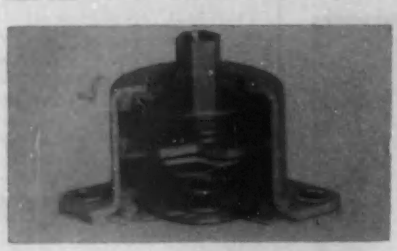
Plants. *In San Diego and Des Moines (photograph above). A total of 1,400,000 sq ft of floor space. Approximately 5,000 employees. Annual sales over $65,000,000.*

Services. *Research, design, development and production engineering staffs. Experienced with all alloy steels, stainless alloys, super alloys, and titanium and its alloys.*

Facilities . . . *for all types of metal fabrication—forming, machining, welding, brazing, casting, coating. Equipped for prototype, limited or mass production. Extensive laboratories. Complete quality control.*

INFORMATION

For more information regarding Solar Gas Turbines or any Solar product or service listed above, write Solar Aircraft Company Department B-35 San Diego 12, California



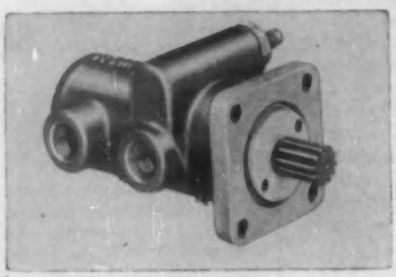
sult, at the worst condition of resonant frequency, mounted equipment will be subjected to less than 300 per cent of the carrier's vibration. Under MIL-C-172B specifications 500 per cent is permissible. At present, only miniature model B22-BB is available, in four spring stiffnesses providing for four maximum loads, ½, 1, 2, and 3 lb per mount. Production of isolators capable of handling up to 40 lb per mount is expected later this year. Barry Controls, Inc., Watertown, Mass.

For more information—
Circle 22, inside back cover

High-Capacity Vibration Isolator

A steel spring vibration isolator recently introduced carries loads of over 17,000 lb each. Its housing is a specially annealed, malleable iron casting. Its adjustable leveling bolt eliminates shims. Korfund Company, Inc., 48-19C 32 Place, Long Island City 1, New York.

For more information—
Circle 23, inside back cover



Two-Element Pump For Gas Turbines

One element of this pump is designed with a relief valve for pressure lubrication of engine bearings and the other element to scavenge oil from the bearing sumps. It is suitable for jet engine or industrial gas turbine lubricating oil, MIL-0-6081 and MIL-0-6082, over a temperature range of −60 F to 300 F.

Each pumping element has a displacement of 0.256 cu. in. per revolution and a rated capacity of 3.2 gpm min at 0 to 2 in.-Hg inlet suction, 50 psi discharge and 3330 rpm. The relief valve is externally adjustable and is normally set at 70 psi cracking pressure to limit pressure in the engine lubrication system. Weight is 2.75 lb. Lear, Inc., Lear-Romec Div., Elyria, Ohio.

For more information—
Circle 24, inside back cover

Double-Enveloping Worm Gear Speed Reducer

This 3½ in center distance speed reducer has a maximum capacity of 13 hp and is available as a standard extended shaft unit, shaft-mounted unit, or either of these in a motorized version. All models are available with

worm over or under, or gear shaft vertical. Tapered roller bearings are used throughout.

All models of the 3½ in. center distance reducer are available in ratiois from 5:1 to 60:1. Additional output speed reductions can be obtained with these new reducers through the use of V-belts and sheaves. Cone-Drive Gear Div., Michigan Tool Company, 7171 East McNichols Road, Detroit 12, Michigan.

For more information—
Circle 25, inside back cover

ELECTRIC POWER, CONTROL

One-Piece Strain Reliefs

The two component parts of these strain reliefs are joined by an integral web of thin, tough nylon. This joining web is flexible and is said not to crack or weaken with handling. The new device holds a cord or cable and insulates it from a chassis. Push, pull and twist are absorbed. These units are available in straight-through or right angle design for all standard wire types and cables. They are UL-approved. Heyman Mfg. Co., 100 Michigan Ave., Kenilworth, N. J.

For more information—
Circle 26, inside back cover

Low Speed Synchronous Induction Motors

A line of synchronous inductor motors featuring slow-speed synchronous operation, instantaneous reversing, acceleration and deceleration has been announced.

Designed for applications requiring moderately high torque at low speeds, synchronous speed operation, or rapid deceleration or reversing, these units are available in torque ratings of 75 and 2 oz-in. at 60, 50 and 25 cps.

Typical applications, according to

CONTINUED ON PAGE 228

TYPE F
STEELFLEX
COUPLING

- Any Size
- Any Service
- Any Application, Horizontal or Vertical
- Always available

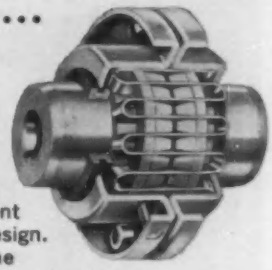
The exclusive grid-groove design of FALK Steelflex Couplings protects your machinery in two ways

You get double protection when you connect your driving and driven machinery with a Falk Steelflex Coupling—the all-steel-built coupling with the exclusive grid-groove design! First, its torsional resilience smothers shock and vibration; and second, the Steelflex design prevents damage and lowered efficiency by accommodating shaft misalignment.

Why have increasing numbers of key men in industry standardized on Falk Steelflex Couplings? Their experience has proved that Falk Steelflex Couplings prolong the service life of their machinery...are trouble-free and need minimum maintenance...are easy to install, lubricate and disconnect ...and cost less per year of service than ordinary couplings.

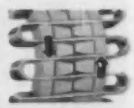
One basic Steelflex design—the Type F, in its many sizes—is adaptable to more than 90% of all industrial applications. This facilitates buying, as well as prompt replacing and servicing when necessary. Write to Department 247 for engineering bulletin, including selection and dimension details.

How shock and vibration are smothered by the FALK Steelflex Coupling's Torsional Resilience...

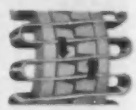


This cutaway view shows the sturdy all-steel construction, also the exclusive, torsionally resilient grid-groove design. Here is how the grid-groove design functions:

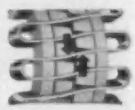
UNDER LIGHT LOADS The gridmember bears only at outer edges of grooves. The long span between points of contact remains free to flex under load variations.



UNDER NORMAL LOADS As load increases, the distance between supports on grooves is shortened proportionately, but a free span remains to cushion shock loads.

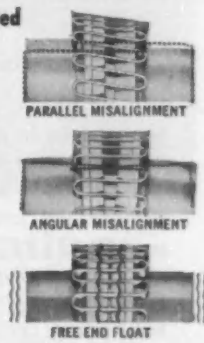


UNDER SHOCK LOADS Under extreme overloads, the gridmember bears fully on the grooves and transmits full load directly. The coupling remains flexible, within its rated capacity.



SHAFT MISALIGNMENT ACCOMMODATED
Free End Float Permitted

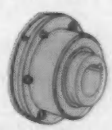
Controlled flexibility in the FALK Steelflex coupling provides compensation for parallel and angular shaft misalignment—and permits free end float for the shafts of the driving and driven members, or of either one.



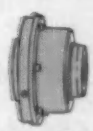
PARALLEL MISALIGNMENT

ANGULAR MISALIGNMENT

FREE END FLOAT



Rapid CM—Reversing Service



H and HH High Speeds

FS—Limited Space

BW—Brakewheel Service

FT—Overload Control

P and PP Extended Shaft

OTHER TYPES AVAILABLE

In addition to the standard Type F (which meets more than 90% of all applications), special or dual purpose Steelflex designs are available for unusual applications. A few of the many types are shown here.

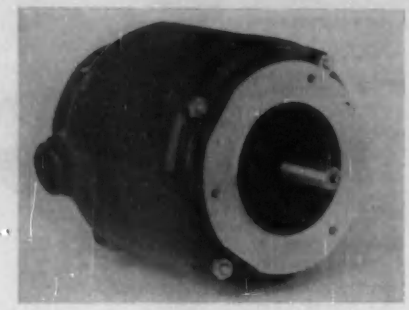
THE FALK CORPORATION, Milwaukee 8, Wisconsin

MANUFACTURERS OF

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

...a good name in industry



the manufacturer, are remote-operated beacons and searchlights, recording devices and control and feed motors. The synchronous characteristics are used by industrial process timers since sufficient torque is developed by the motors to operate cams and levers, eliminating the need for a second motor or a solenoid in many applications. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 27, inside back cover

Molded Printed Circuits

This printed circuit is completely enclosed in a molding process which transforms the assembly into single compact unit. Improved moisture resistance and less change in load life is claimed. In addition, these units offer lower voltage coefficients, greater shelf-life stability and stable improved temperature coefficients. They are unaffected by vibration.

These circuits are available with round copper wire terminals and tab leads. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

For more information—
Circle 28, inside back cover

Synchronous Gear Motor

A two-speed, synchonous gear motor in which speeds are changed electrically provides outputs of 1800 and 300 rpm. Speed reduction is accomplished by electrically reversing the motor, and picking up a gear train through an internal over-riding clutch. The output shaft rotates in the same direction at either speed.

The basic motor is of the permanent split-capacitor type. It is de-

signed for operation on 115 v, 60 cps, and takes 10 w at rated load. Holtzer-Cabot Motor Div., National Pneumatic Co., Inc., 125 Armory St., Boston 19, Mass.

For more information—
Circle 29, inside back cover

Integral Gearmotor

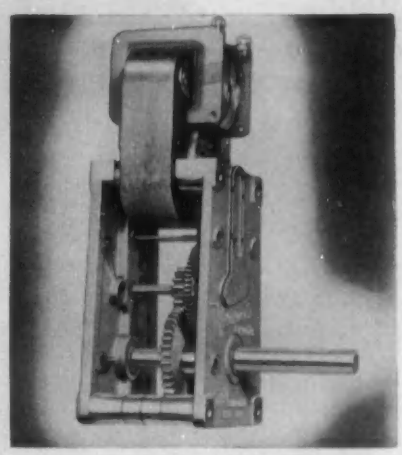
This gearmotor's speeds range from 25 min per revolution to 4000 rpm. The horsepower ratings range from $\frac{1}{4}$ to 75 hp. The gearmotor shaft is directly aligned with and coupled to the electric motor shaft by a male and female connection. Starting and running are quiet and smooth in gearmotors of any speed range.

Ball bearings are used throughout and all gears are helical, reversible, and built according to AGMA standards. A-c motors, drip-proof and totally enclosed, furnish the power. J. D. Christian Engineers, 480 Potrero Ave., San Francisco 10, Calif.

For more information—
Circle 30, inside back cover

Gearmotor for Continuous Or Intermittent Duty

This gearmotor has high starting torque characteristics. It is rated at 120 to 500 oz-in. at 10 rpm, depend-



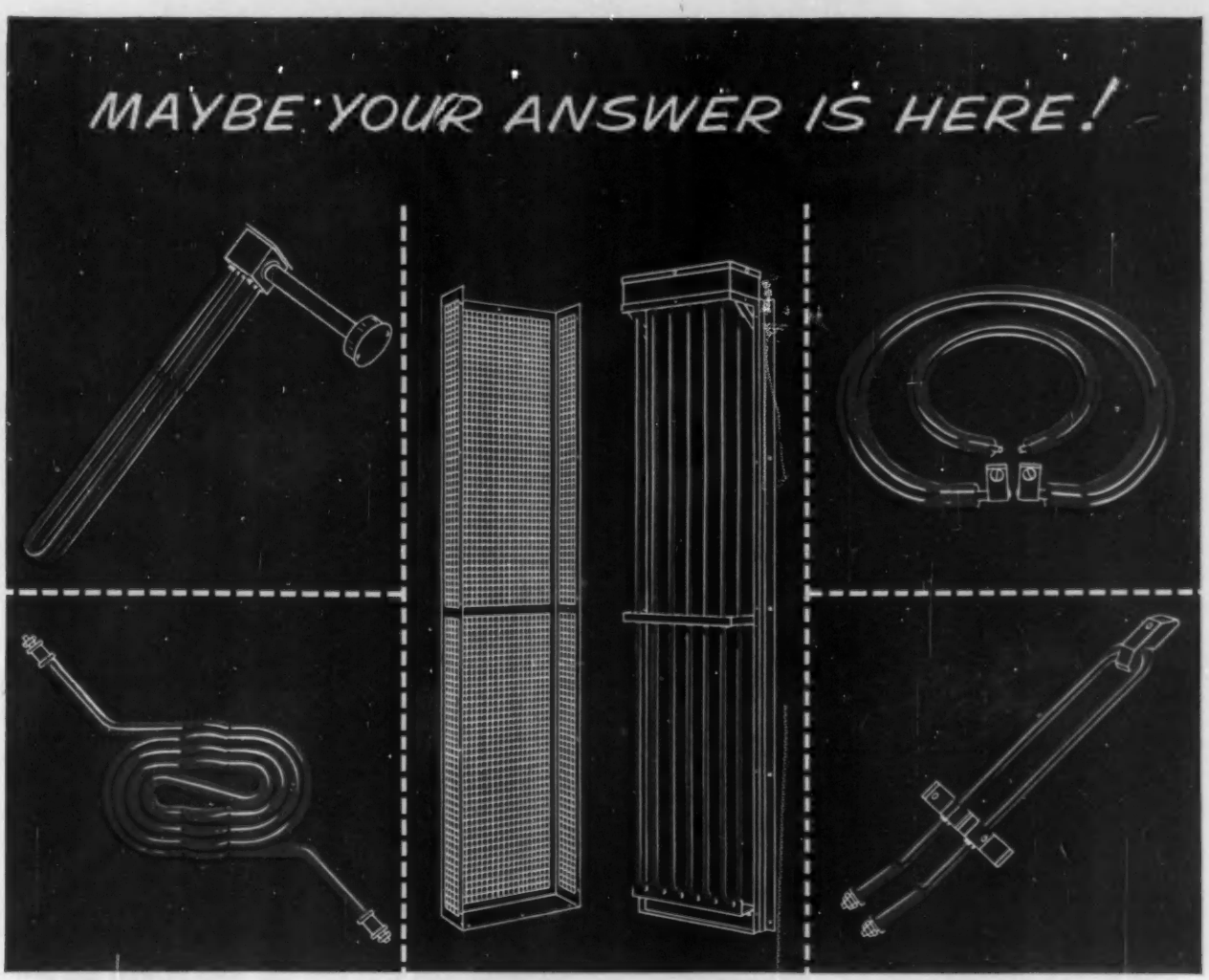
ing on duty cycle. Output shaft can be geared to 3 rpm and up. Standard output shaft diameter is $\frac{7}{16}$ to $\frac{3}{8}$ in., cut to desired length, with other sizes available. Length is $5\frac{1}{2}$ in., width $2\frac{13}{16}$ in. and depth $1\frac{9}{16}$ in. Operating voltage is 115 v with 60 cps as standard. Motoresearch Co., 1602 Junction Ave., Racine, Wis.

For more information—
Circle 31, inside back cover

Permanent Magnet Motor Generator

This miniature inverter converts 28v, dc, direct to 400 cps, ac. Equipped with governors for maintaining constant speed, it operates over an input range of 18 to 30 v, dc, and an output of 90 to 150 v, ac. Available in 25, 100 and 250 va ratings, the units with standard winding put out 115 v. Designed for 1000 hr through an ambient temperature range of −55 C to 71 C, the units withstand 10 G acceleraton and meet military requirements for noise suppression. The new inverter in the 100 va model weighs 7 lb and occupies

CONTINUED ON PAGE 230



Check FERROD first for Electrical Heating!

There's no trick to finding the *right* answers ... provided you know where to look for them. And in electrical heating it pays to look to Ferrod, for here you will find the range of products and technical help you need to find that *one* best answer.

Here at Ferrod we have but one business, the designing and building of electrical heaters. Each is made for a specific application—and in its design we consider many things beyond size, shape, wattage, voltage and terminals.

When we analyze your heating problem, our engineers delve into controls, mountings, heat patterns, allowable heat-up time, heat losses, sheath metals, safety margins and a host of other factors—all important to you if you are to get dependable, long-lived, economical units. And we often find we can use a *standard* element, thus saving the cost of special engineering and tooling.

Ferrod produces a full line of rod, finrod, immersion, cast-in-place and clamp-on electrical heaters. Why not write and tell us what *you* need, or ask to have one of our representatives call!

FERROD
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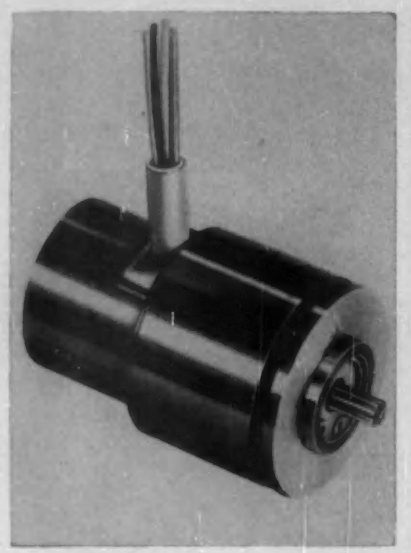
FERROD ELECTRIC HEATERS

FERROD MFG. CO. *(Subsidiary of Ferro Corp.)*
612 N. RIVER STREET • BATAVIA, ILLINOIS

a space 6.4 x 4.6 x 4.4 in. Arga Div., Beckman Instruments, Inc., 220 Pasadena Ave., S. Pasadena, Calif.

For more information—
Circle 32, inside back cover



Brake and Servo Motor Unit

Guaranteed by the manufacturer for 100 hr operation at 125 C, this instant stopping brake-servo motor unit instantly responds to excitation at −65 C. No preliminary warm up is necessary at low temperatures. Theoretical acceleration is 12,000 radian per sec and stopping time is 0.02 sec with no external inertia loading.

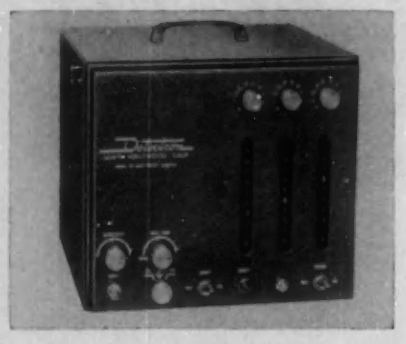
The entire unit measures 0.938 x 1.5 in. length. Weighs 2.56 oz. No-load speed is 7,000 rpm and stall torque is 0.30 oz-in. Input power is 3 w per phase and input current with rotor stalled is 175 ma. John Oster Mfg. Co., 1 Main St., Racine, Wis.

For more information—
Circle 33, inside back cover

Preset Counters

Any electrical, mechanical or optical event which can be converted into electrical impulses can be counted and controlled by this unit, it is claimed. Transducers to effect electrical impulse conversion may be photocells, magnetic coils or switches.

Offered in five models, count capacities, dependent on the number of decades, range from 100 to 1 million. All units operate on 117 v, ± 10 per cent, 50-60 cps. Net weight varies from 15¾ lb on the DS-8602 to 20¾ lb on the DS-8606. Detectron Corp., 5528 Vineland Ave., North Hollywood, California.



For more information—
Circle 34, inside back cover

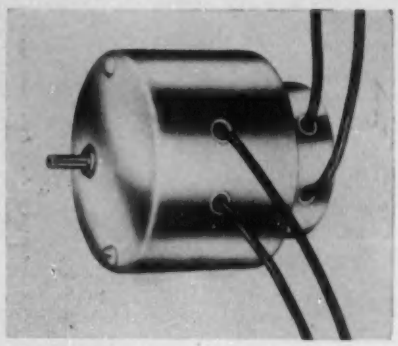
Electrical Counters

These counters are said to have a 50 million count-life, 1000 counts per min rating, 7 w power consumption, balanced armatures for reliable operation on airborne equipment and quiet operation with no a-c hum when energized. They come in a one-piece die-cast housing with cover held by concealed screws.

Wiring leads are brought out through the center of the housing bottom affording added protection against dust for basemount models, as well as convenient wiring from either end or rear through small wiring ports in the rim of the base. The housing bottom lead exit also affords a wiring location for panelmount models.

The new counters are made in six-digit models with large white figures on black number wheels. Reset to zero is made by a single turn of the knob. Available for practically any voltage up to 120 v, ac or dc. Overall dimensions, less reset knob, of basemount model are 2½ x 3½ x 1.668 in. wide. Panelmount model: 4⅞ x 1⅞ in. Production Instrument Co., 702-10 W. Jackson Blvd., Chicago 6, Ill.

For more information—
Circle 35, inside back cover



Reversible Electric Motor

This motor measures 2 x 2 x 2 in. and has a torque rating of 5 lb-in. at 1 rpm. It is designed to operate on 115-v, 60-cycle current. Speed range is from 10 rev per hr to 1800 rpm. Bristol Motor Div., Vocaline Co. of America, Inc., Old Saybrook, Conn.

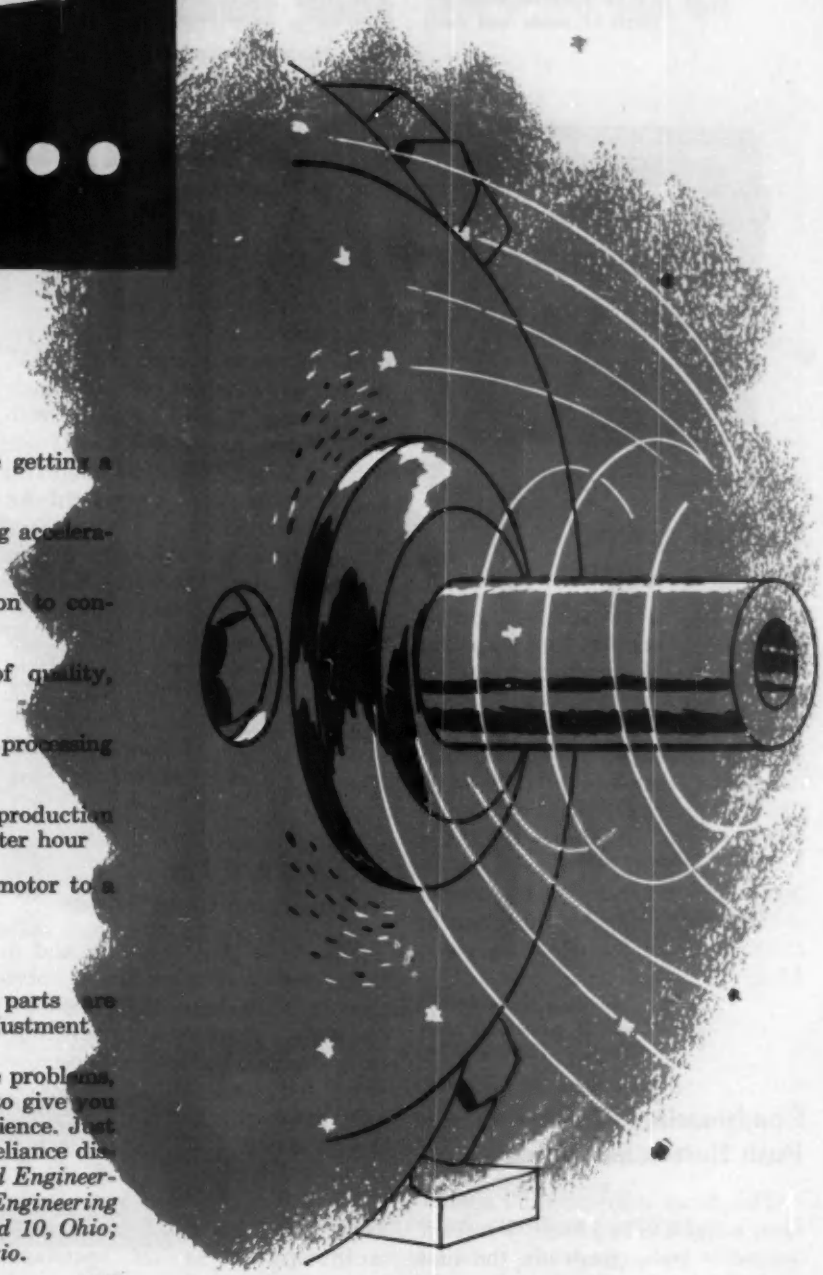
For more information—
Circle 36, inside back cover

Impact Counter

This counter will count metallic or non-metallic parts of any weight or size, according to the manufacturer. Actuated by an impact accelerometer, the unit is intended to replace such counting methods as magnetic search

CONTINUED ON PAGE 232

IF...



- You are spending too much time getting a tool to and from an operation
- You are having trouble controlling acceleration under tension
- You need a more precise operation to control scrap
- You need hair trigger control of quality, quantity and size
- You want to start and stop your processing line faster
- You would like to leave your production line virtually unattended hour after hour
- You require re-acceleration of a motor to a previous exact speed
- You want centralized control
- Your mechanical transmission parts are wearing out or getting out of adjustment

Or if you have other motor-drive problems, our sales engineers are prepared to give you the benefit of our 50 years' experience. Just get in touch with your nearest Reliance district sales office, or write to *Applied Engineering Division, Reliance Electric & Engineering Co., 1080 Ivanhoe Road, Cleveland 10, Ohio; Canadian Division, Welland, Ontario.*

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RELIANCE ELECTRIC AND ENGINEERING CO.

Builders of the Tools of Automation

coils, photo-electric systems, batch weighing. It will handle rates up to 250 per min. Control Devices, Inc., 8299 East 9 Mile Road, Van Dyke, Michigan.

For more information—
Circle 37, inside back cover

Timer Registers Operating Hours

This electrically activated device automatically registers total operating hours of any electrical equipment or motor-driven machine. Less than 4 x 2⅜ in. deep, it is designed for surface mounting. It registers tenths of hours or minutes, then repeats. The meter can be supplied for registration up to 99,999.9 hr or min. Rating is 110-125 v, 60 cycle, 2 w, ac. For circuits of higher voltage a resistor or transformer is supplied. Capeway Instrument Corp., Bedford St., E. Bridgewater, Mass.

For more information—
Circle 38, inside back cover

Combination Push Button and Timer

This device is intended for applications where it is important to regulate accurately and consistently the time interval related to the start of a cycle. Further applications include cascade arrangements where one unit starts the cycle and modified additional units time out successive intervals, each energizing circuits in turn. Various circuits with or without relays can produce a variety of action.

These timers are available in time ranges from 10 sec to 80 hr. The units are adjusted by means of a knurled thumbnut, which permits adjustment of the pointer and tripper on the dial. The dial resets automatically after each cycle and repeats within ½ per cent of overall range. Seely Instrument Co., Inc., 4 St., at Canal, Niagara Falls, N. Y.

For more information—
Circle 39, inside back cover

Electronic Timer

An electronic timer with ± 2 per cent repeat accuracy permits multiple modes of operation including interval, delayed action, repeat cycle and single cycle timing. It can be supplied with standard time ranges of 0.3 to 25 sec, or 0.5 to 50 sec. The 270 F calibrated dial assembly can be removed for remote operation.

No stand-by power is required; cold cathode tubes eliminate warm-up time. The isolated load contacts are rated at 5 amp. Both semi-dusttight and oiltight enclosures are available. Ferrara Inc., 8106 W. Nine Mile Road, Oak Park, Mich.

For more information—
Circle 40, inside back cover

Time Switch For Intermittent Operations

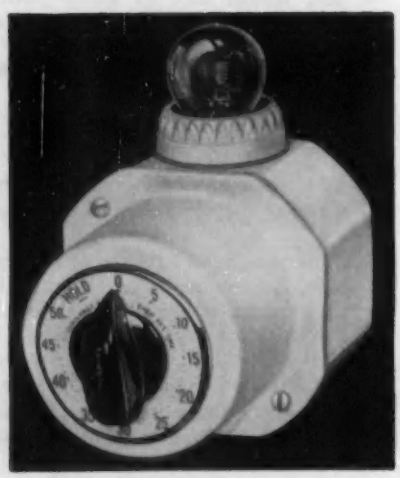
This 24-hr time switch is said to make control of intermittent operations including day or night shutdown, completely automatic. It was originally designed for marginal operation of oil well pumps, cycling of processing equipment, heating, ventilating and air conditioning systems, stokers, oil and gas burners.

The dial is scaled in 15 min graduations which can be set for as many as 48 "on" and 48 "off" operations, automatically repeating a 24-hr schedule. Adjustment for the complete schedule is simply and easily made by sliding the self-contained, non-removable trip levers in or out on the dial. Switch is available with or without a calendar device to cut out non-working days, and the unit is com-

pletely selective for all seven days of the week.

Overall dimensions are 8¼ x 6½ x 4½ in. deep. Rated capacity is 1000 w. The time switch operates on 60 cps, ac, 110 or 240 v. Switch is single-pole, double-throw. Zenith Electric Co., Dept. PEN, 152 W. Walton St., Chicago 10, Ill.

For more information—
Circle 41, inside back cover

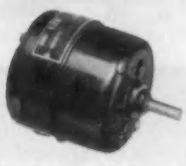


Time Switch

This switch is designed for industrial equipment or appliances that require an electrical circuit to open or to close at the end of a specified time period. The unit is available in

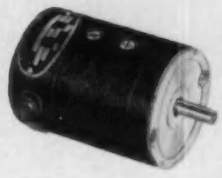
CONTINUED ON PAGE 234

in just a few days...you can get a standard Howard Fractional H.P. Motor to test



#11A—1/45 to 1/30 H.P.

#1109—1/16 to 1/8 H.P.



#100—1/50 to 1/13 H.P.

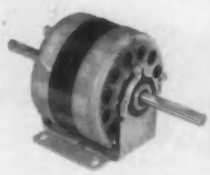
#200—1/200 to 1/75 H.P.

#512—1/20 to 1/10 H.P.

#700—1/8 to 1/2 H.P.

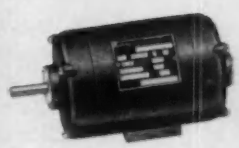
#2800—1/30 to 1/70 H.P.

#3000 GEAR MOTOR—
OUTPUT 120 IN. LB.



#5000—1/15 to 1/8 H.P.

#2500—1/300 to 1/1400 H.P.



#2900—1/100 to 1/15 H.P.

Universal and D.C. Motors
1/1000 to 1/2 H.P.

Shaded Pole Motors
1/2000 to 1/8 H.P.

Induction Motors
1/1400 to 1/4 H.P.

If you are searching for the right motor to fit your quantity application, check today with the people at Howard. 85,000 applications over the past 25 years means broad experience and a wide range of motor types and specifications—in fact, the largest line of fractional H. P. motors in the field. Just a representative few are shown here so if you don't see what you need, write today and tell us your requirements. We'll answer your inquiry promptly. Many standard motors are immediately available for your preliminary tests. Write, wire or phone; we'll handle your inquiry or sample order promptly.

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DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS

four time ranges: 0 to 7, 0 to 14, 0 to 28 and 0 to 56 min, respectively.

The clock mechanism has machine-cut gears with steel shafts, polished pivots set in brass end plates and a balanced hair spring and escapement to assure accurate timing. Current rating is 115 or 230 v, ac, 10 amp. W. M. Cissell Mfg. Co., Louisville, Ky.

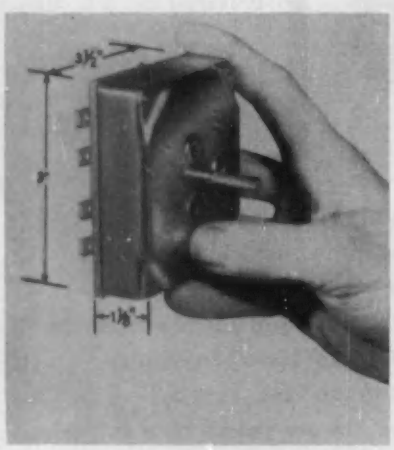
For more information—
Circle 42, inside back cover

Pump Control Switch

This control has been designed for applications requiring protection on loss of pressure or to initiate a cycle of operation on rising pressure. The device is capable of operation at pressures up to 80 psi. Both single and doubl-pole versions are available.

A toggle and over-center arrangement insures "snap action" in the make and break of the contacts. Range and differential are easily adjusted in the field. The differential can be varied from 10 to 30 psi. Square D Co., 4041 N. Richards St., Milwaukee 12, Wis.

For more information—
Circle 43, inside back cover



Appliance Timer

This timer was designed for regulating the timing cycles of home clothes driers. The entire device is completely enclosed. Load rating is said to be high, to meet the demands of continuous, heavy-duty operation.

A wide range of timing cycles is available. Number and type of terminals will be furnished as required. The timer will operate in any position. Haydon Mfg. Co., Torrington, Conn.

For more information—
Circle 44, inside back cover

Pressure Switch

This switch is designed for water systems, low pressure air compressors, paint sprayers and similar applications requiring 1 hp or less. It has a capacity up to 65 psi. Normal pressure settings are 20 to 40 lb. Furnas Electric Co., 1050 McKee Street, Batavia, Illinois.

For more information—
Circle 45, inside back cover

Enclosed Snap-Action Switch

This switch is rated at 10 amp, 125 v, ac; 5 amp, 250 v, ac, ½ hp, 125/250 v, ac. It is enclosed in a molded plastic case which protects the mechanism from dirt, abuse and tampering. A nylon button actuator provides a means of operating the switch. The switch may be furnished with operating forces as low as 25 g.

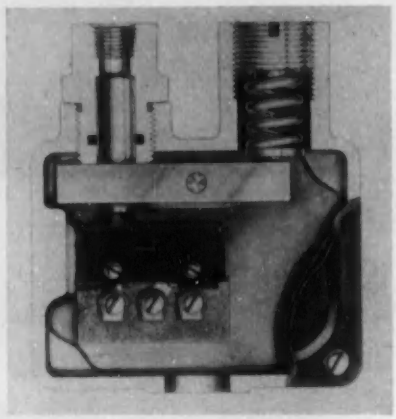
The new switch is a single-pole, single-throw type and is available either normally open or normally closed. Cherry Electrical Products Corp., 3080 Skokie Valley Road, Highland Park, Ill.

For more information—
Circle 46, inside back cover

Piston-type Pressure Switch

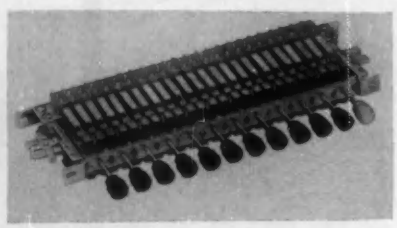
These switches accurately sense any system pressure over an adjustable range of 35 to 12,000 psi, with a proof range of 4500 to 20,000 psi. The piston bore and piston are honed and ground. A sealed piston is used to simplify installation and eliminate the need for drain return piping. Generous piston travel is asserted to prevent undesirable actuation from line surges, jarring or vibration.

The switch will actuate an electric



circuit at any predetermined point on increasing or decreasing pressure. The fixed actuation value varies from 15 to 1000 psi. There is an external adjustment screw for field setting which is locked in place to avoid its accidental disturbance. The switch incorporates a UL-approved switching element rated for a-c and d-c currents. Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

For more information—
Circle 47, inside back cover



Switch Has Up to 12 Stations

This switch is supplied in any multiple from two to 12 stations. There is a choice of mounting centers. Center to center distance between buttons is ⅝ in. Plungers are designed to accept standard push-on buttons. Stack switches can be mounted on separate plates—up to four stacks can be operated by each button. Switching action between stations is so controlled that contacts of a released station will return to normal before contacts of newly operated station are actuated.

Switches can be provided with fine silver contacts or with welded cross bar palladium contacts. Depth required behind panel is 3-17/64 in.

CONTINUED ON PAGE 236

How Harvey puts aluminum to work for you...

Here are a few of the many ways Harvey makes your product easier to manufacture, easier to sell

EXTRUSIONS... For decorative as well as basic parts, custom-designed aluminum extrusions replace riveted and welded assemblies... simultaneously increase strength and simplify fabrication.

STRUCTURALS... High strength, light weight, workability, corrosion resistance. Aluminum extrusions combine all four... are ideal as basic load-bearing members.

MACHINING STOCK... Harvey deep-drawn hex and round stock set a new mark in uniform grain structure—consistent from surface to core. This means fast, chatter-free cutting, long tool life, few rejects and true threads.

FORGING STOCK... If you make your own forgings in quantity, Harvey extruded forging stock can save many intermediate steps. Custom-designed extrusions whose cross sections approximate the forged blanks may be cut to length.

EXTRUDED PIPE AND TUBE... Seamless... uniform in structure, size and shape... clean and smooth inside and out... easily formed. Usable in applications ranging from portable irrigation systems to aircraft heat exchangers.

DRAWN TUBE... Combines strength and high finish... ideal for TV antennas, furniture, and similar products. Cold drawn for structural uniformity ... temper specially controlled for workability.

PRESS FORGINGS... Where parts must combine maximum strength with savings in weight, cost and manpower, Harvey aluminum forgings often completely solve a designer's problem.

IMPACT EXTRUSIONS... Thin-walled, tubular structures can be produced by this method and held to very close tolerances. Machining is practically eliminated, and scrap is greatly reduced.

AUTOMATIC SCREW MACHINE PRODUCTS ... The West's largest installation of multiple-spindle screw machines can reduce your manufacturing costs. Harvey carries your job through every step—from engineering through quality control.

Forty years of solving the special and difficult design problems of industry have developed the "practical imagination" that characterizes the entire Harvey approach. Our Field Engineers will gladly sit down with your own designers to determine in detail how Harvey's experience can put aluminum to work making *your* product easier to manufacture, easier to sell.

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HARVEY Aluminum

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in Sweets' File for Product Designers

RESEARCH... DEVELOPMENT... PRODUCTION... Harvey does all three as a leading independent producer of aluminum extrusions in all alloys and all sizes, special extrusions, press forgings, hollow sections, structurals, rod and bar, forging stock, pipe, tubes, impact extrusions, aluminum screw machine products and related products. Also similar products in alloy steel and titanium on application.

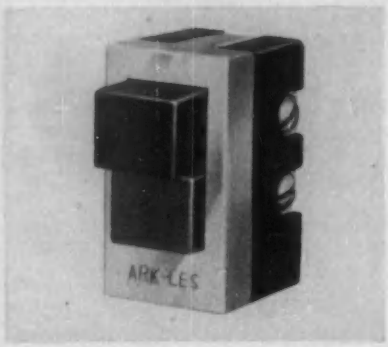
Length depends on number of stations. Height is variable depending on the circuit. Switchcraft, Inc., 1328 N. Halsted St., Chicago 22, Ill.

For more information—
Circle 48, inside back cover

Wire-Wound Controls

These controls have a wiper arm insulated from the shaft and mounting bushing. Rated at 1 w, they are available in resistance values from 2 to 1,000 ohm. Clarostat Mfg. Co., Inc., Dover, N. H.

For more information—
Circle 49, inside back cover



Pushbutton Switch

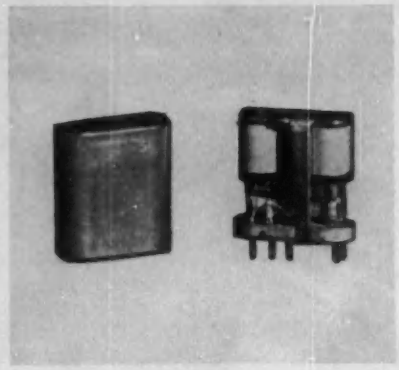
These switches are designed for applications requiring on-off, single or double-pole, single-throw controls. Rated at 20 amp, 125 v, and 10 amp, 250 v, ac/dc, they are $\frac{11}{16}$ x $1\frac{3}{4}$ x $1\frac{11}{16}$ in. depth. Ark-les Switch Corp., 51 Water St., Watertown 72, Mass.

For more information—
Circle 50, inside back cover

Miniature 2-amp Relay

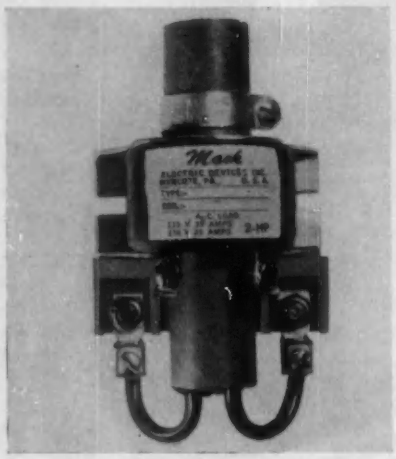
This hermetically sealed relay is believed to be the smallest of its rating ever developed. It is less than 1 in. high; weighs 10 g. Contact rating is 2 amp resistive load at 30 v, dc, or 115 v, ac. A balanced armature design is said to give resistance to shock and vibration.

Rated for operation at 1.5 millisecond, the sealed relay has contact springs of beryllium copper, designed



to hold their adjustment indefinitely during temperature cycling and storage. Shock and vibration resistance of the micro-miniature relay is high, with shock rating of over 50 G, and vibration resistance of 10 to 55 cps at 0.12 in. max excursion and 55 to 500 cps at 20 G acceleration. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 51, inside back cover

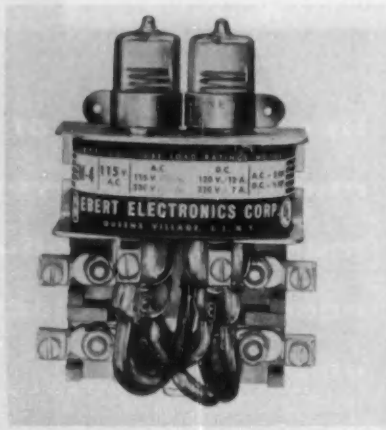


Mercury Plunger Relay Resists Breakage

This relay has a protective fiber cylinder. Tungsten contacts are hermetically sealed within the tube and mercury is used to make and break the coil circuit in inert gas. The relay is dust and moistureproof and there is no wear on the coil, frame or terminal assembly. One moving part—the plunger—is of special magnetic stainless material with a ceramic liner.

The relay takes 60 millisecond to close, 40 to open. The coil is cotton interwoven, varnish impregnated and baked, providing assurance against coil failure due to atmospheric conditions. Available in a range of coil voltages, the contacts handle motor loads up to 2 hp with current loads up to 35 amp at 115 v ac, 25 amp, 230 v ac, and 10 amp, 115 v, dc. The relay is 2-$\frac{3}{8}$ x $4\frac{1}{2}$ x 2-$\frac{1}{4}$ in. deep. Mack Electronic Devices, Inc., Wyncote, Pa.

For more information—
Circle 52, inside back cover



Two-Pole Mercury Relay

This relay is rated at 35 amp or 2 hp at 115 v, ac. The heavy duty version is rated at 60 amp at 115 v, ac. The d-c ratings of both models are 12 amp at 120 v and 7 amp at 220 v. Both units are UL-approved at their published ratings for inductive and non-inductive control applications. Ebert Electronics Corp., Queens Village, New York.

For more information—
Circle 53, inside back cover

Thermal Time Delays

Although these relays are completely hermetically sealed, their time delay intervals (1/10 to 5 sec) are adjustable by means of a screw accessible from the top. Standard energizing voltages range from 6.3 to 28 v and the relays may be energized interchangeably on dc or on ac of any frequency.

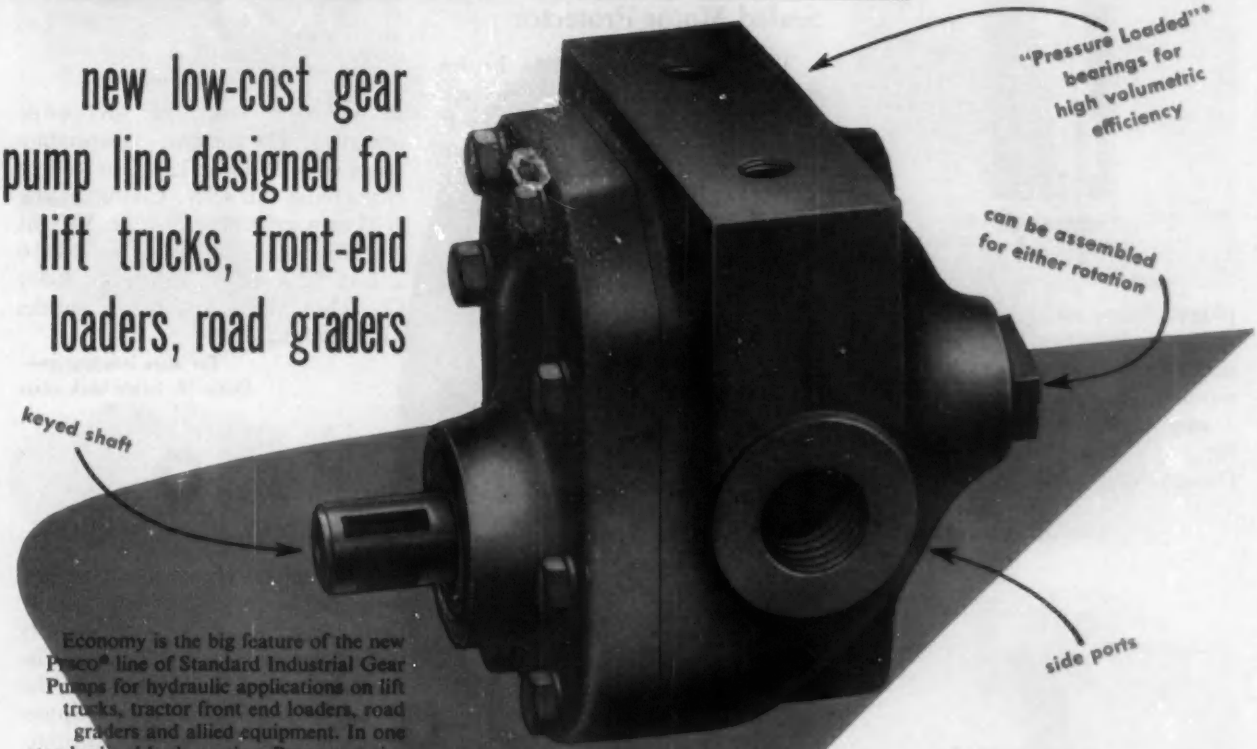
These relays are $\frac{3}{4}$ x 2-$\frac{3}{8}$ in. high. Both flanged and seven-pin miniature

CONTINUED ON PAGE 238

New from Pesco!

standard industrial hydraulic pumps . . .

new low-cost gear pump line designed for lift trucks, front-end loaders, road graders

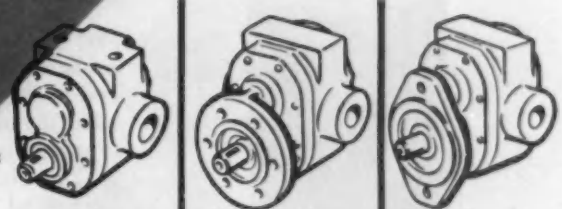


Economy is the big feature of the new Pesco® line of Standard Industrial Gear Pumps for hydraulic applications on lift trucks, tractor front end loaders, road graders and allied equipment. In one standardized body casting, Pesco can give you a choice of three displacement sizes and three mounting arrangements at a price you will want to investigate.

And these pumps are not built down to a price. They are Pesco quality in every aspect of design and manufacture. For example, they incorporate Pesco's patented "Pressure Loaded" bearings for maximum efficiency and sustained new pump performance throughout an extra-long service life.

If you want to build superior hydraulic performance *plus* economy into your off-the-road or materials handling equipment, get the full story on these new Pesco Pumps. Contact your local Pesco sales engineer or write: PESCO, 24700 North Miles Road, Bedford, Ohio.

three convenient mounting arrangements:



base | round flange | magneto flange

	Pump Model Series	Rated Flow GPM	Displacement Cu. In.	Pressure PSI	Rated Speed RPM
available in three popular capacities:	051002	10.0	1.32	2000	2000
	052973	12.0	1.56	2000	2000
	052941	16.0	1.93	1500	2200

*Pesco's patented principle of gear pump construction.

engineering Pesco production

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BORG-WARNER CORPORATION

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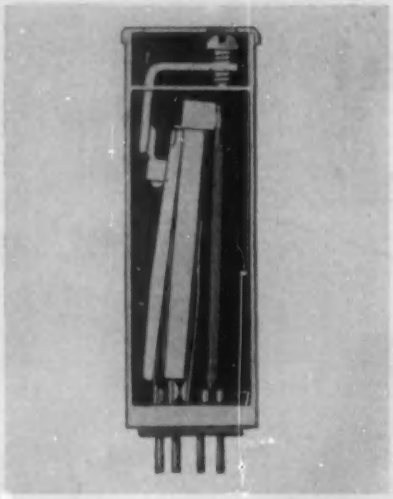
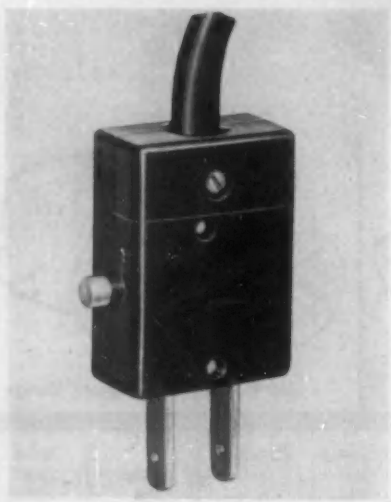


plug-in forms are available. Weight is 1 oz. Contacts are single-pole, single-throw, either normally open or normally closed. Contact rating is 3 amp at 115 v, ac. G-V Controls Inc., 28 Hollywood Plaza, East Orange, N. J.

For more information—
Circle 54, inside back cover



Cord-End Circuit Protector

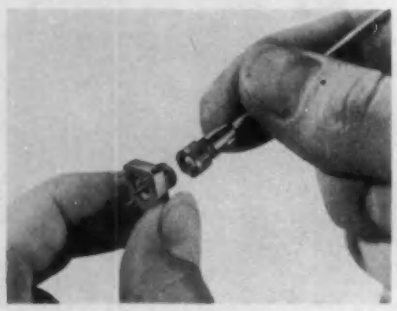
This protector, for electrical appliances, is designed to protect 3 to 10 amp circuits. In case of an interruption, service can normally be restored within 10 sec by pressing the reset button. Yet it is trip-free; it will not maintain a circuit that has not been cleared. This same reset button warns the user (when tripping is persistent) that a service check up is necessary. Mechanical Products, Inc., 1840 River St., Jackson, Mich.

For more information—
Circle 55, inside back cover

Sealed Motor Protector

This protector is said to be impervious to impregnation cycles and offers certified calibration at ± 5 F. Standard models are rated at 10 amp, 115 v or up to 5 amp, 230 v. Fasco Industries, Inc., 255 N. Union, Rochester 2, N. Y.

For more information—
Circle 56, inside back cover



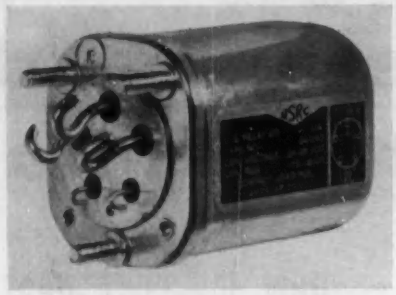
Miniature Printed Circuit Connector

The connector consists of a coaxial plug assembly and a receptable that can be mounted on a printed or etched card by five terminal points using the solder dip method. The plug assembly is approximately ¾ in. in length and 9/32 in. dia. Receptacle has a mounting base of 7/16 sq in. The five terminals, 0.040-in. dia, are of plated phosphor bronze. The shells are machined from brass and are plated. Terminals can be furnished for 1/16, ⅛ and ¼ in. card thicknesses. H. H. Buggie, Incorporated, 726 Stanton Street, Toledo, Ohio.

For more information—
Circle 57, inside back cover

Relay Has High Vibration Resistance

Vibration immunity up to 10 G between 10 and 500 cps and ability



to withstand shocks of 30G while operating in ambient temperature range of −65 C to 125 C is said to characterize this relay. Contact rating is 25 amp resistive at 29 v, dc. Weight is 0.225 lb and dimensions are 2-1/16 x 1-31/32 x 1-7/16 in. U. S. Relay Co., 1744 Albion Street, Los Angeles 31, California.

For more information—
Circle 58, inside back cover

Resistor With Transparent Encapsulation

Manufacturer claims that this resistor's transparent encapsulation minimizes service failures due to normally undetected bubbles or strains. The winding is electrically welded to the phosphor bronze leads and requirements of Mil-R-9BA are met. Shallite, Inc., 10 Mill St., Paterson, N. J.

For more information—
Circle 59, inside back cover

Miniature Trip-Free Circuit Breaker

This circuit breaker has the conventional button action. A manual push resets it. Disc-type thermal element with double-break and wiping contacts assures permanent calibration.

CONTINUED ON PAGE 240

look to

WESTERN GEAR for

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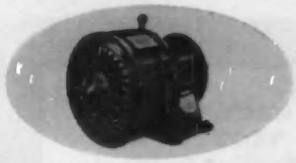
- specialized machinery for every purpose
- complete line of electro-mechanical catalog products
- gears of all types and sizes

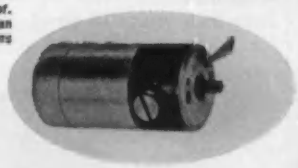
Illustrated are only a few of the wide variety of both custom and standard products designed and manufactured by Western Gear.



Torq-Master, used with torque converters and fluid couplings in the lumber industry

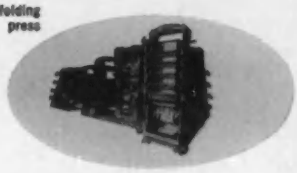
Giant gear and rack

Right angle vertical pump drive

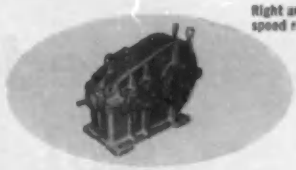


Miniature motor. One of more than 50 basic designs

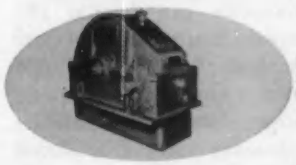
Pacific, G-E gearmotor



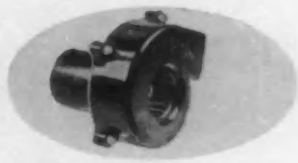
Manifolding press



Right angle speed reducer

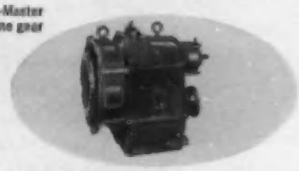


High speed unit

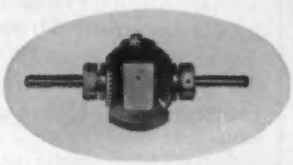


Centrifugal blower, one of many design sizes

Helicopter rotor drive unit

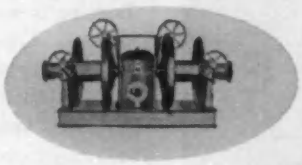


Sea-Master marine gear



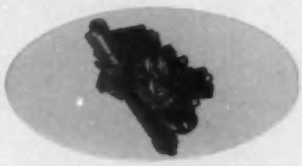
Miniature precision differential unit

Aircraft cable drum type hoist, hydraulic, pneumatic or electric drive



Trawl winch

Rotary actuator powered by both hydraulic and electric motors. One of hundreds of basic designs



Horizontal stabilizer actuator unit. AC and DC power providing three speeds for manual, auto pilot and coarse control

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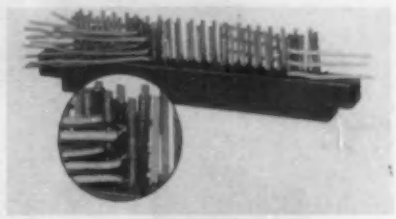
The D6761 has high rupture capacity and has successfully handled over 2000 amp, 120 v, ac, 400 cps and 6000 amp, 10 v, dc. The new breaker is available in ratings from 5 through 35 amp. Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Massachusetts.

For more information—
Circle 60, inside back cover



Solderless Printed Circuit Connector

This connector can handle 132 solderless connections of No. 24 wire and accomodates 0.093 in. printed circuit board. Gold plated spring temper phosphor bronze contacts are used. A polarizing stud can be placed at any contact point on the connector.

Molding compounds include a choice of mineral-filled Melamine, Plaskon-reinforced Alkyd 440A or Orlon-filled diallyl phthalate. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

For more information—
Circle 61, inside back cover

Germanium Diodes

Complete hermetic sealing of the housing is said to be provided in these diodes. Glass-to-metal and welded metal-to-metal seals are used throughout. International Rectifier Corp., El Segundo, Calif.

For more information—
Circle 62, inside back cover

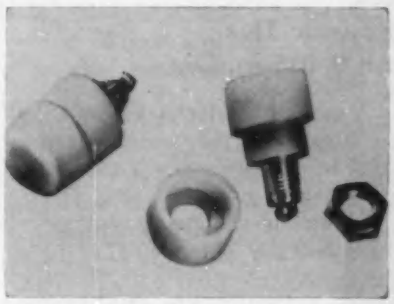
Deposited-Carbon Resistors

Pure crystalline carbon is deposited on a ceramic insulator by means of thermal decomposition on a ceramic insulator by means of thermal decomposition of a hydro-carbon to make these resistors. Higher resistance values are attained by spiral-cutting through the coating. The resistance

element is protected either by multiple layers of insulating, moisture-resistant varnishes separately baked on, or by hermetically sealing in an impervious steatite shell.

These new resistors meet standard tolerances of ±5 per cent and, when required, down to 1 per cent. Clarostat Mfg. Co., Inc., Dover, N. H.

For more information—
Circle 63, inside back cover



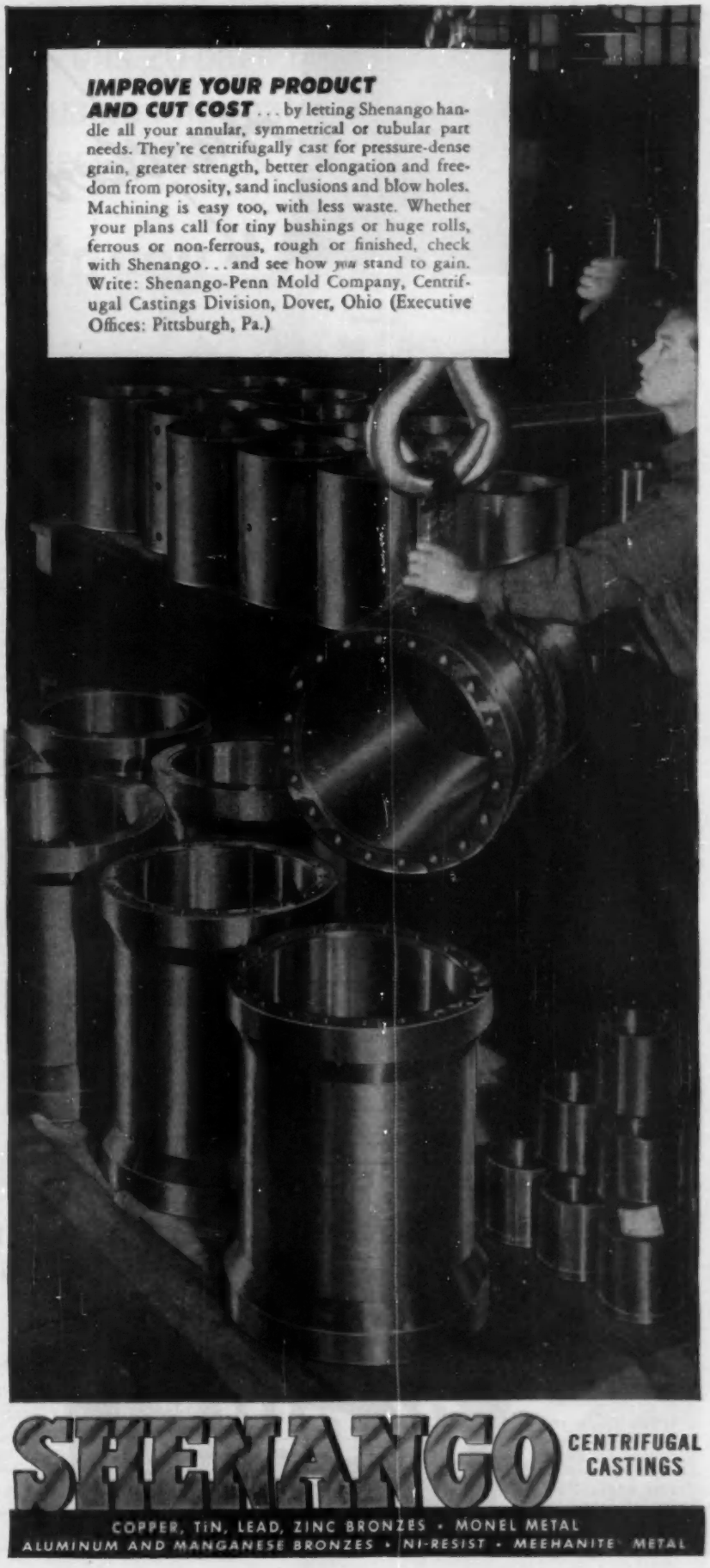
High Voltage Nylon Tip Jack

The nylon insulation is said to be sufficient to withstand more than 10,000 v, dc. The nylon cap washer affords protection against shorting and is designed so that the jack is adjustable to panels ranging in thickness from $\frac{1}{16}$ to $\frac{1}{4}$ in. The one-piece phosphor bronze spring contact accommodates standard 0.080 in. plugs, and is pretinned for easy soldering.—Robco Mfg. Div., Pilot International Corp., 27-01 Bridge Plaza N., Long Island City 1, New York.

For more information—
Circle 64, inside back cover

Electric Cords for Portable Equipment

A line of portable cords includes three types. One of them, designed for unusually severe applications where cords are exposed to the elements and subjected to abrasion, crushing, impact, shock, moisture, oils, grease and acids, meets the requirements of the Federal Bureau of Mines and Pennsylvania Dept. of Mines. Another cord resembles that approved for mines in all respects, except that the neoprene jacket is cured by continuous vulcanizing. The jacket is free-stripping and can be used in automatic stripping machines. The third cord is for appliances, office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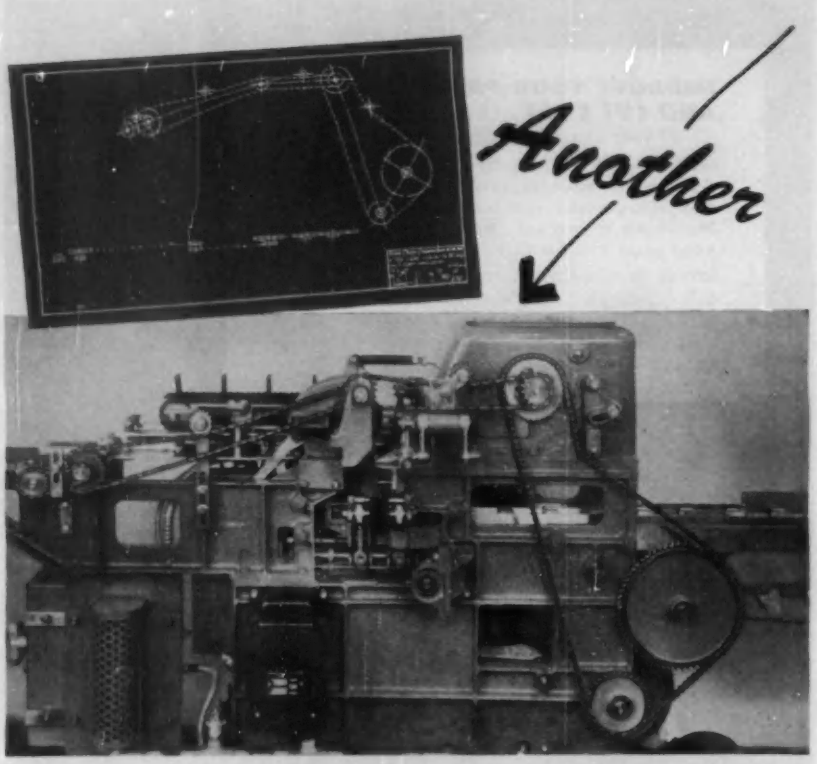
COPPER, TIN, LEAD, ZINC BRONZES • MONEL METAL
ALUMINUM AND MANGANESE BRONZES • NI-RESIST • MEEHANITE METAL



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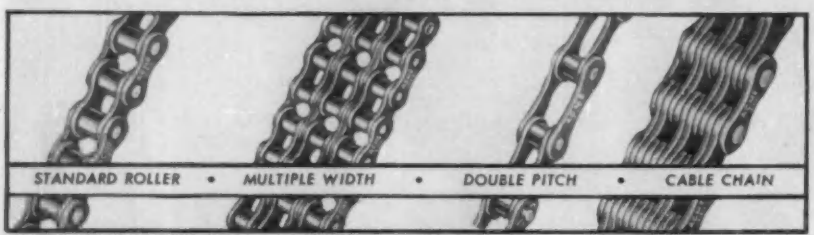

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Cords are packaged in standard 250 ft coils in individual cartons which are labeled in a single area. Service cords sizes No. 18 and No. 16 are packed on 250 ft. spools in individual cartons. Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.

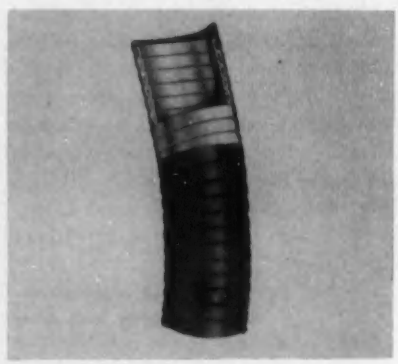
For more information—
Circle 65, inside back cover

Resistor Has An 0.015 in. Dia.

A molded resistor measuring 0.140 in. long with 1 in. leads is rated at 1/10 w. Voltage rating is 150 v max, continuous, rms or dc.

Maximum continuous wattage at 70 C is 0.1 w and at 40 C is 0.2 w. Derates linearly from 0.1 w to 70 C to zero at 100 C. Allen Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wisconsin.

For more information—
Circle 66, inside back cover



Watertight Electrical Conduit

This conduit consists of an impervious polyvinyl jacket over a flexible, galvanized steel core. The flexible core is said to blend around tight radii, permitting it to hug the contours of a machine or installation. The vinyl jacket resists scuffing, abrasion and rough handling, as well as being liquidtight.

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527H HOUGH STREET
Barrington, Illinois

is exposed to coolants, moisture, fats, greases, chemicals. Columbia Cable & Electric Corp., 255 Chestnut St., Brooklyn, N. Y.

For more information—
Circle 67, inside back cover

Non-Rigid Plastic Tubing

This Teflon tubing is said to have a tensile strength of not less than 1500 psi, minimum breakdown voltage of not less than 5000 v, rms, and complete flexibility to −90 C. Inside diameter runs from a minimum of 0.014 to a maximum of 0.112 in., with wall thicknesses running from 0.008 to 0.012 in.

This tubing is available in a variety of solid and striped color combinations. Hitemp Wires, Inc., 26 Windsor Ave., Mineola, N. Y.

For more information—
Circle 68, inside back cover

"Stop-Start" Control Circuit

This automatic "stop-start" control circuit is housed in a dustproof panel box and is reported to offer split second accuracy during thousands of working hours. It is presently being used in operations such as these: sequence operations, load transfer, machine tools, fuel flame control, textile machines, warning panels, superheaters and micro-wave equipment. Industrial Control Panel Co., 517 W. Monroe St., Chicago 6, Ill.

For more information—
Circle 69, inside back cover

Machine Cycle Control System

This control system consists, basically, of a control box and either dual hand buttons or a single foot switch for each operator on the machine. Electrical energy from standard plant voltages is "stored" in the control box until both hand buttons are depressed, or until the foot switch is depressed, disconnecting the plant voltage and simultaneously releasing the stored electrical energy to operate the air motor through a solenoid control valve. With the supply of stored

WHAT'S NEW IN MOTOR CONTROL? ★ ★ ★ GET IT FIRST IN CUTLER-HAMMER

Now industry's three-phase motors can have full three-phase protection with standard in-stock motor control!

Many motor users have proved *two* overload relays are inadequate protection for three-phase motors. In fact, widespread motor burnouts due to inadequate motor protection have caused amendment of Section 4327 of the National Electrical Code. The code now permits authorities to *require* three overload relays in three-phase motor control . . . and this provision is already being enforced in some areas. Many safety experts and power engineers say the time is not far off when three-phase motor control with less than three overload relays will be unacceptable.

The use of three overload relays is not new. Many industrials plagued by recurring motor burn-outs and the resulting intolerable operating interruptions have changed to three-relay control. But such changeovers have been slow to effect and costly as no standard control was available with three overload relays. Special constructions and enclosures have always been required.

The BIG news today is that this is no longer true. The new Cutler-Hammer ★ ★ ★ Motor Control offers *three* overload relays in all standard starter constructions and enclosures. You pay only for the third relay, nothing additional for special engineering or manufacture. No extras. No delays. It is *in stock* at your nearby Cutler-Hammer Authorized Distributor. Order it today and use it tomorrow. CUTLER-HAMMER, Inc., 1332 St. Paul Avenue, Milwaukee 1, Wis.

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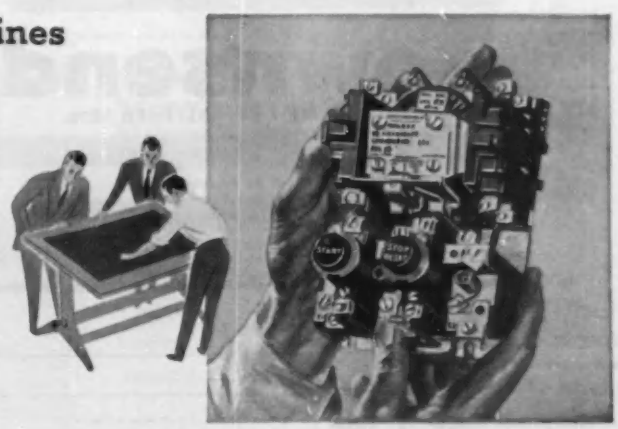
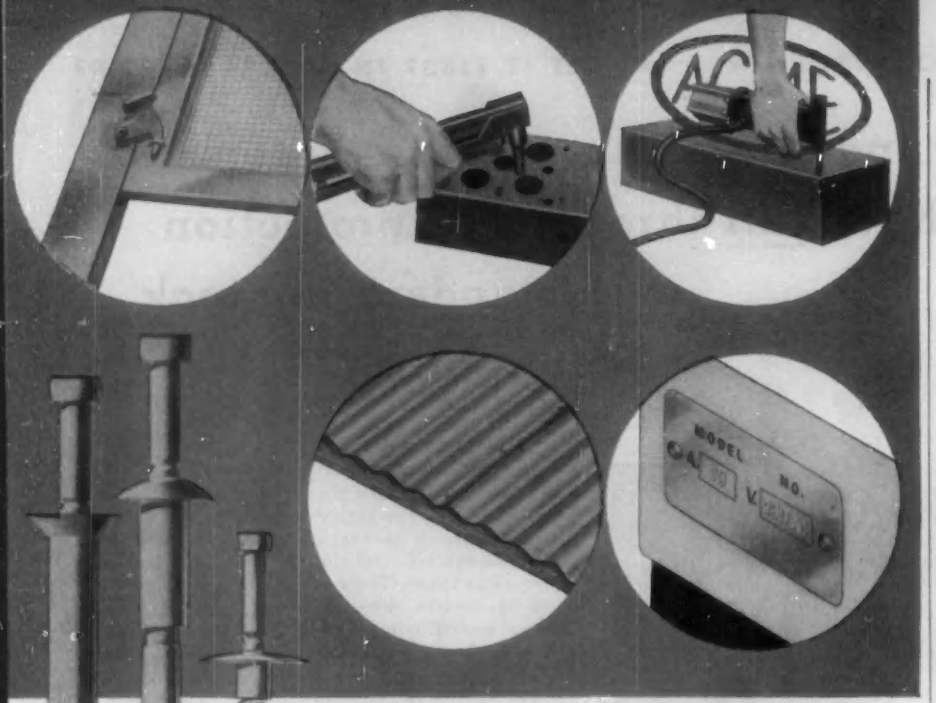
★ ★ ★
MOTOR CONTROL
C-H

For designers of machines and special control panels

The unit panel construction of Cutler-Hammer ★ ★ ★ Motor Control makes it easy to incorporate starters with three overload relays. Starters mount in place with only three screws, require no more space than starters with only two overload relays. NEMA Sizes 0, 1 and 2 starters and all parts thereof are now available as components. Also a complete companion line of control relays with quickly interchangeable NC-NO contacts. Be sure you have the latest design data on this advanced equipment. Write or wire today.





You Speed Assembly— Reduce Costs... with Townsend Blind Rivets

In a split second, one man can install this tamper-proof, vibration-resistant blind rivet to give you secure fastening in many applications that otherwise would be slow and expensive.

Townsend blind rivets are installed by one man from one side of the work and are used extensively in blind and limited clearance operations. They provide high clinch and a strong fastening method for a wide variety of products.

These rivets are ideal for installation of name plates and serial numbers on appliances and similar units which must retain their original identity permanently. Radio and television components are assembled quickly with Townsend blind rivets. Awnings, jalousies, screens, storm doors and windows are fabricated with ease in the shop or in the field when Townsend blind rivets are used. The illustrations above are but a few representative items where these ingenious rivets are used to keep unit costs down by saving time.

For information, write for Bulletin TL-99 or use the coupon below.

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electrical energy exhausted, hand buttons or foot switch must be released to permit recharging of the control for the next machine cycle.

Foot switch can be set to provide repeat cycle, as it usually is installed in conjunction with approved types of guards enclosing dangerous areas. An external on-off switch is mounted on the control box. All other controls are inside the control box, protected from tampering by a locked door. An interlock switch cuts off the electrical current if the control box door is left open, preventing unauthorized change of the pre-set cycle. Toggle switches are provided for: 1) selection of hand or foot operation; 2) non-repeat or continuous cycle. Security Controls, Inc., Dept. 6D, 255 Franklin St., Buffalo 2, N. Y.

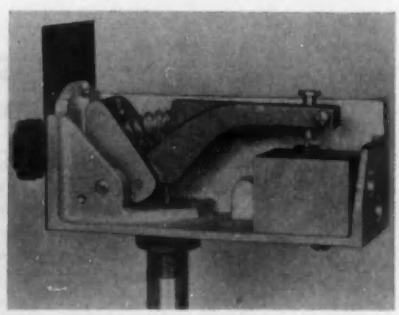
For more information— Circle 70, inside back cover

Servo Multiplier

This servo multiplier group consists of two single channel servo multipliers and one power supply. Each servo channel is capable of multiplying five variable d-c voltages by a sixth. Servo channels may be provided with sine-cosine, secant, tangent or special non-linear function potentiometers.

Frequency response with 10 per cent amplitude is flat to within ±1 db to 5 cps, flat to within ±3 db to 12 cps. Dynamic accuracy is said to be 0.5 per cent at 0.5 cps. Velocity limit is 1000 v per sec. Dynalysis Development Laboratories, Inc., 11941 Wilshire Blvd., Los Angeles 25, Calif.

For more information— Circle 71, inside back cover



Pneumatic Temperature Control

This device is for controlling and varying the flow of gas, steam or other

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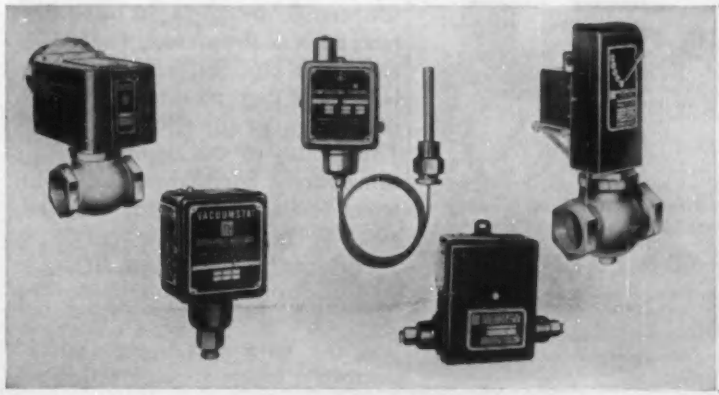

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Automatically filters air and regulates air pressure. Replaceable, transparent or metal bowl. ¼", ⅜". Series 5A and 5N.

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LUBRO-CONTROL UNIT (Model 3745A-2) typical combination of Norgren Automatic-Drain Filter, Pressure Regulator and Micro-Fog Lubricator.

Phone the Norgren representative listed in telephone directory classified section under "Norgren Pneumatic Products" or

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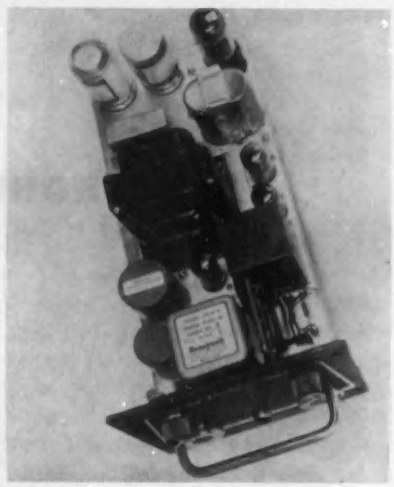
medium with an air-operated valve or motor. It may be used in any pneumatic system up to 50 psi and will reduce the output or branch line pressure as temperature increases. Since it operates by the differential expansion of solids and uses no liquid or vapor fill, it is available for temperatures up to 1800 F.

Temperature adjustments are made with a knob on the front of case. Throttling ranges are fixed, but may be specified as narrow as 5 deg or as wide as 100 deg. Burling Instrument Co., 16 River Road, Chatham, N. J.

For more information— Circle 72, inside back cover



Proportional Amplifier

A selective range d-c proportional amplifier, designed for use as a preamplifier in recording measurement systems or as an amplifier in highly sensitive control systems, was recently announced. A second-harmonic magnetic converter is used as the input modulator. Interchangeable plug-in range units and optional isolated input are included. The optional isolated input is said to be particularly useful in temperature measurements using thermocouples or thermistors. The plug-in range unit provides the desired combination of gain and bandwidth which is optimum for any given application. This section of the amplifier can be conveniently interchanged for a different combination of gain and bandwidth by changing plug-in units.

Full-scale voltage ranges as low as 100 microvolt may be selected. The noise level is less than 5 microvolt and long term drift is less than 10 microvolt. Linear response within ±1

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Reducing compressed air line pressures to proper working pressure for each piece of air-operated equipment is essential for high operating efficiency, long equipment life, and low maintenance costs.

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Nearly 400 standard models to meet your needs
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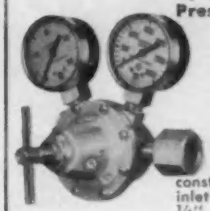
Air Regulators
Reduce line pressures as high as 400 psi to desired working pressure. Four spring ranges to choose from for best performance — 50, 75, 125 or 250 psi maximum delivery. ⅛" through 1" pipe sizes. Series 2A.

Pilot-Controlled Air Regulators, Integral Type
Extreme precision over wide operating range. Reduce line pressures as high as 400 psi to desired working pressure from 2 psi to 120 psi. Three spring ranges to choose from for best performance—30 psi, 60 psi or 120 psi maximum delivery. ½", ¾", 1" pipe sizes. Series 20AC.



Cylinder Gas Pressure Regulators
Single-stage regulators to reduce cylinder gas pressures as high as 3000 psi to desired working pressure. Choice of four spring ranges for best performance — 50, 75, 175 or 450 psi maximum delivery. Close, constant pressure control. 2 inlet ports, 3 outlet ports. ¼" pipe size. Series 4C and 6C.

Relieving-Type Air Regulators
Reduce line pressures as high as 400 psi to desired working pressure. Four spring ranges to choose from for best performance — 50, 75, 125 or 250 psi maximum delivery. The relieving feature protects connected equipment against abnormally high pressures. ⅛" through 1" pipe sizes. Series 2AX.

Pilot-Controlled Air Regulators, Remote Control Type. Extreme precision over wide operating range. Reduce line pressures as high as 400 psi to desired working pressure from 2 psi to 120 psi. Three spring ranges to choose from for best performance—30 psi, 60 psi or 120 psi maximum delivery. ½", ¾", 1" pipe sizes. Series 20AA.

Liquid Pressure Regulators
For lines carrying water, oil, non-corrosive liquids up to 200° F. Reduce line pressures as high as 400 psi to desired working pressure. Choice of four spring ranges for best performance—50, 75, 125 or 250 psi maximum delivery. 5 pipe sizes—⅛" to 1" inclusive. Series 2H.

Precision Air Regulators, Relieving Type
Reduce line pressures as high as 400 psi to desired working pressure. Air flow up to 2 cfm with 30 psi maximum delivery. Also for flows of less than 1 cfm with maximum delivery pressures of 60 or 120 psi. ¼" pipe size. Series 11,400.

Low Pressure Air Regulators
Reduce line pressures as high as 250 psi to desired working pressure. Choice of 2 spring ranges for best performance—40 or 60 psi maximum delivery. ¼" pipe size. Series 1505.

Steam Pressure Regulators
For lines carrying saturated steam and hot water with temperatures up to 450° F. Reduce line pressures as high as 400 psi to desired working pressure. Choice of four spring ranges for best performance—50, 75, 125 or 250 psi maximum delivery. ½", ¾", 1" pipe sizes. Series 2B.

Low Capacity Regulators for Air or Liquids
Reduce line pressures as high as 400 psi to desired working pressure. Choice of 2 spring ranges for best performance—50 or 175 psi maximum delivery. 2 inlet ports and 3 outlet ports. ¼" pipe size. Series 3A2-B.

Butane Pressure Regulators
For primary stage pressure regulation on industrial and large domestic applications. Reduce line pressures as high as 250 psi to desired working pressure up to 50 psi. ½", ¾", 1" pipe sizes. Series 2E.

Regulator-Filter Unit
Automatically filters air and regulates air pressure. Replaceable, transparent or metal bowl. Choice of 3 filter elements. With or without pressure gauge. ¼" and ⅜" pipe sizes. Series 5A and 5N.

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per cent may be extended from dc to as high as 80 cps.

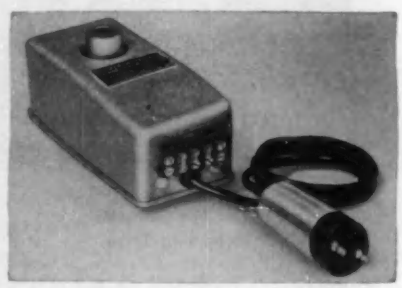
This unit is a portable instrument, weighing 20 lb and measuring 6-⅞x6-⅛x14 in. deep. It can be bench or rack mounted. Doelcam, Div. Minneapolis-Honeywell Regulator Co., Soldiers Field Road, Boston 35, Mass.

For more information—
Circle 73, inside back cover

Magnetic Servo Amplifier

This magnetic servo amplifier can be used to operate any two-phase, 400 cps servo motor requiring up to 15 w, 57 v to the control phase. When used with a simple vacuum tube or transistor preamplifier, it may be employed in control systems. In all cases, unit will deliver reversible phase a-c output for reversible phase ac or reversible phase d-c input. Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.

For more information—
Circle 74, inside back cover



Multi-Purpose Transducer Component

Built around this manufacturer's ionization transducer, this component provides a ready-to-use unit for analog conversion of changes in capacitance to changes in voltages. It may be applied to the measurement of any physical phenomena which can be resolved into changes of capacitance. The output is a phase-sensitive d-c signal as high as 60 v, providing a basis for display, recording and control of variables.

Designed to be adaptable to many problems, it may not provide the complete requirements in some specific applications. When such requirements arise, the new transducer can be designed into a special system

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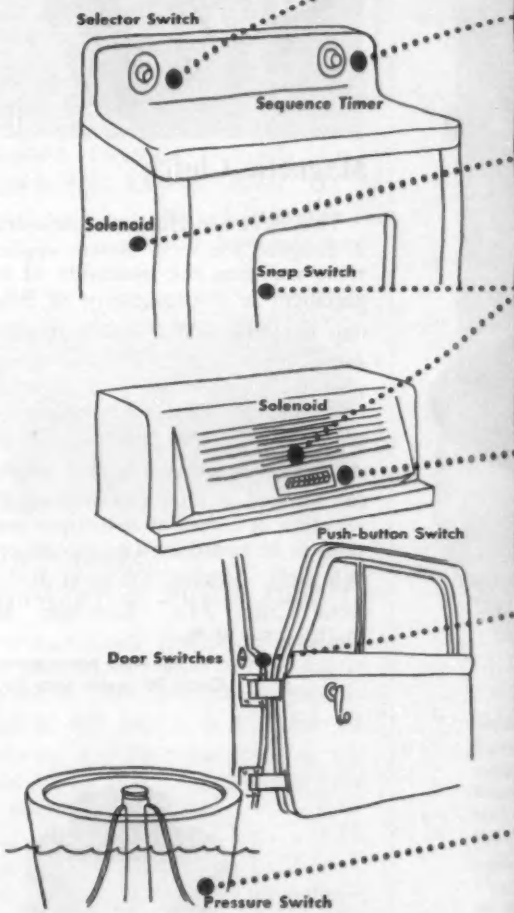
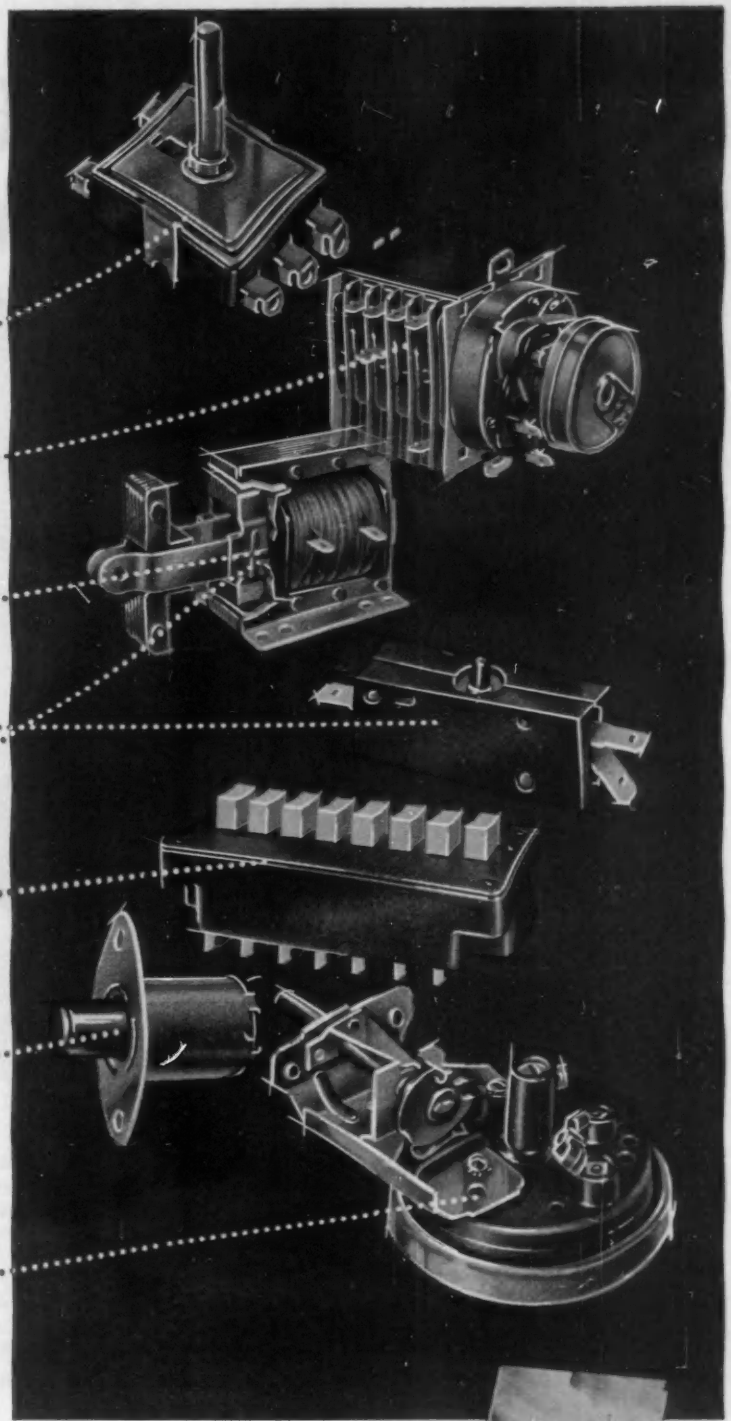
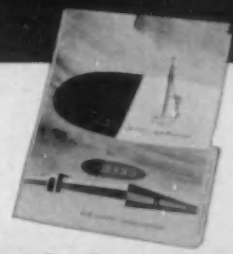
Some of the Applications
of Soreng-Designed Controls





Soreng controls can be custom designed— to meet your specific requirements—at mass production prices.

For complete facts write for your data folder on Soreng Controls



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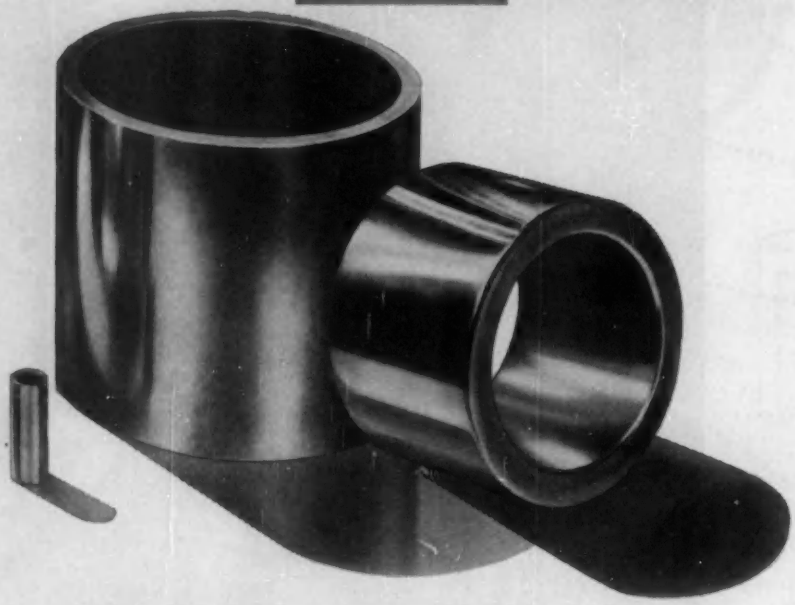
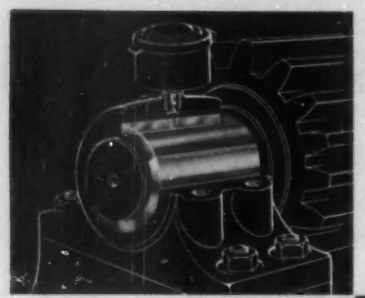


The Cast Bronze Bunting Bearing is delivered ready for installation—with the easy assembly in housing and on shaft all that is necessary. No lock nuts, lock washers, end covers are required to increase initial cost and assembly cost. Bunting engineers will gladly aid you in making specifications for the Bunting Bronze Bearing that exactly meets your need. There is a Bunting engineer near you for consultation, or write our Product Engineering Department at Toledo.



Where the Bunting Bearing is the floating type it is inserted by hand. Where the pressed—in type is employed, the bearing is simply pressed into the gear, gear box, lever or housing.

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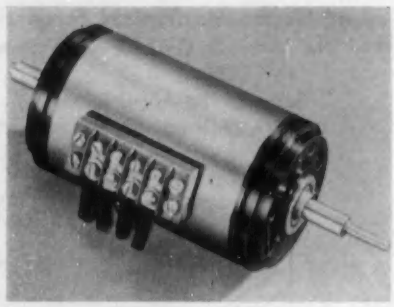
or equipment. The unit measures 7/ x 3 in. and weighs 1½ lb. Decker Aviation Corp., 1361 Frankford Ave., Philadelphia 25, Pa.

For more information—
Circle 75, inside back cover



Magnetic Clutch

This electro-mechanical component is designed for servo system applications requiring the possibility of engagement or disengagement of either one or both output shafts from a single input shaft. This is accomplished by enclosing two magnetic coils and two sets of couplings in one housing. The functions of the shafts may be reversed so that outputs can be used as inputs, permitting the selection of either of two input rotations to be transmitted to a single output shaft. Sterling Precision Instrument Corp. 34-17 Lawrence St., Flushing 54, N. Y.

For more information—
Circle 76, inside back cover

Variable Transformers

Two new models of variable transformers recently introduced include a cased unit for laboratory and industrial use which has an extractor type fuse, jeweled pilot light, output receptacle cord, plug and on-off switch.

The second model is an uncased unit, for back of panel mounting.

The molded, die-cast bases are reinforced and so designed as to provide internal mounting dimensions if required. The uncased model has a shaft that can be loosened with a single screw without upsetting adjustment between rotor brush and commutator surface. Standard stock models can be used for special shaft length applications without cutting the shaft. A tap wired to the terminal board provides 6 v for a pilot light when the unit is panel mounted.

Both units have an input voltage of 115 v; maximum load rating, 1.0 kva; output voltage, 0 to 115v and 0 to 135v; maximum output 7.5 amp. Standard Electrical Products Co., 2240 E. 3 St., Dayton, Ohio.

For more information—
Circle 77, inside back cover

Low-Voltage, Low-Current Power Supply

A dual-output, regulated power supply provides an output of 0 to 50v at 50 ma per side. Regulation from no-load to full load is better than 0.1 percent. Output impedance is less than 1 ohm at dc, output ripple, 3 mv or better. Panel size: 7 x 9 x 11 in. deep. Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena 8, Calif.

For more information—
Circle 78, inside back cover

Work Solenoid

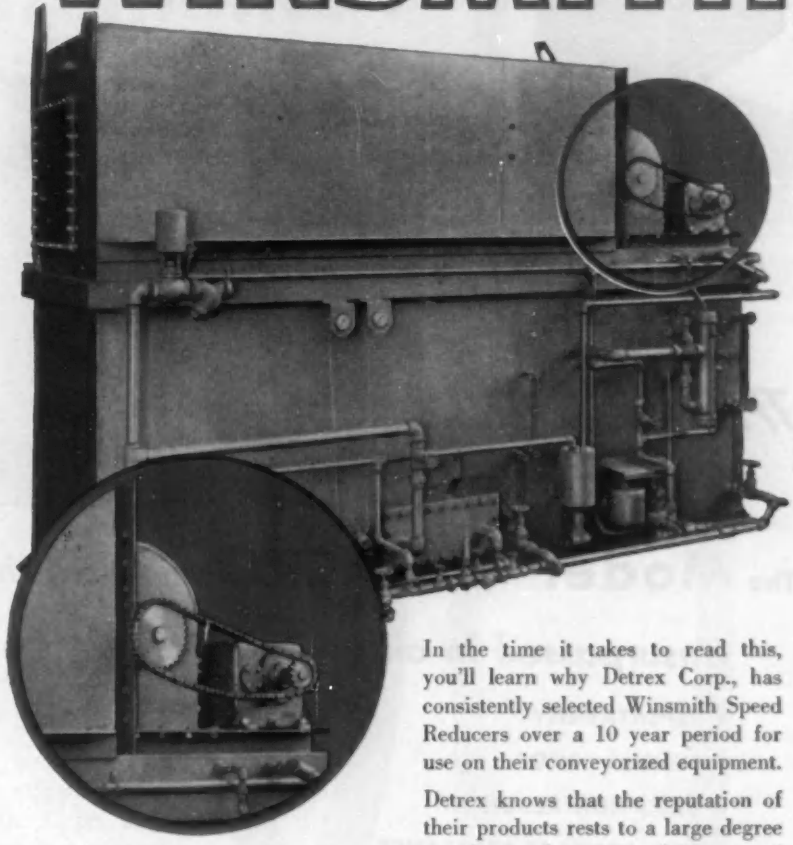
This is an electro-mechanical device which converts rotating shaft positions into decimal form to actuate card or tape punch devices, electric printers or similar read-out devices. Operated by 28 v, d-c current, this solenoid unit must remain energized at all times except when a read-out switch is closed, at which time the contacts and brushes become engaged.

The model illustrated is a single-coil push type, rated at 18 to 30 v, dc,

In less than 5 minutes...

BENEFIT FROM DETREX'S 10 YEARS EXPERIENCE WITH

WINSMITH SPEED REDUCERS



Detrex selected a 4½ DB Winsmith Speed Reducer for use on their unique rotary basket gyro degreaser. Driven by a ¼ hp motor at 1750 rpm with a reduction ratio of 960 to 1, the Winsmith reducer provides a smooth, vibrationless operation that eliminates the possibility of damage to delicate machined parts.

In the time it takes to read this, you'll learn why Detrex Corp., has consistently selected Winsmith Speed Reducers over a 10 year period for use on their conveyorized equipment.

Detrex knows that the reputation of their products rests to a large degree on the performance of the speed reducer they select. *Dependability* is their prime specification . . . and, Detrex reports "Virtually no failures in 10 years" as the reason Winsmith Speed Reducers are continually used on equipment carrying the Detrex Name Plate!

Apply this 10 year record of dependability to your own speed reducer problems! In addition to ruggedness and reliability, you can count on Winsmith for the most complete line of speed reducers from a single source within the range of 1/100 to 85 hp. in ratios of 1.1:1 to 50,000:1. A Winsmith power transmission specialist is available to discuss your speed reducer applications. You'll find him listed in the classified section of your phone directory; or, write Winsmith, Inc. direct.

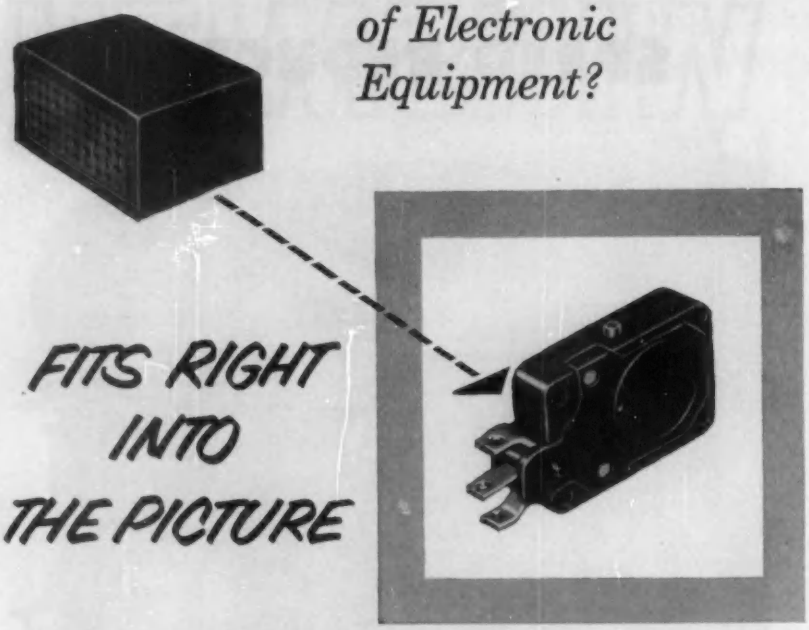
...a single source for the most complete line of speed reducers within the range of 1/100 h.p. to 85 h.p. in ratios of 1.1:1 to 50,000:1

WINSMITH SPEED REDUCERS

POWERED BY ACME

WINSMITH, INC.
111 Eaton St.
Springville, (Erie County) N. Y.

Got A Small "Black Box" *Crammed full of Electronic Equipment?*



The **Model "M" ACRO** *micro-switch*

Unsurpassed in all these ways...

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- VIBRATION RESISTANT
- LOW CONTACT RESISTANCE
- TEMPERATURE RANGE +165° F. to -90° F.
- DIMENSIONALLY STABLE AT ABOVE TEMPERATURES
- WIDE RANGE OF OPERATING FORCES
- CLOSE MOVEMENT DIFFERENTIALS

HELPFUL SWITCH APPLICATION GUIDE

Whether your problem is meeting rigid government specifications for weather and altitude or controlling circuits on sensitive electronic equipment, this data in charted form will greatly simplify your switch selection. Write for Data Sheet M-1.

"The Biggest Line of Little Switches"

ACRO MANUFACTURING COMPANY
ACRO SWITCH DIVISION
COLUMBUS 16, OHIO
Plants at Columbus and Hillsboro, Ohio
REPRESENTATIVES IN ALL PRINCIPAL CITIES

for continuous duty. Minimum pull available at the beginning of the stroke is 1.85 lb at 0.125 amp, 78 F and 24 v, dc. Stroke is 0.1-in. Weighing 0.42 oz, the Model 9300 is 2-$\frac{3}{32}$ x 1-$\frac{1}{4}$-in. dia. Carruthers & Fernandez, Inc., 1501 Colorado Ave., Santa Monica, Calif.

For more information—
Circle 79, inside back cover

Voltage-Frequency Control

Presently available in two models, VF-60, for 60-cps outputs, and VF-400, for 400 cps, this control permits conversion from any d-c source voltage to any a-c output voltage, within the ratings of the controlled machine. Units can be built for any power frequency. Standard units regulate both output voltage and frequency to within ±2 per cent. Electric Regulator Corp, 314 Pearl St., Norwalk, Connecticut.

For more information—
Circle 80, inside back cover

Silicon Rectifier For 125 C

These rectifiers are said to overcome the basic disadvantages of selenium, germanium and gas-filled tubes. In most applications, efficiencies of 90 to 99 per cent are achieved. Their hermetically sealed construction provides permanent protection against the environment. Types range in power handling ability from 10 amp at 50 v to 5 amp at 200 v, at 125C. Transitron Electronic Corp., Melrose, Massachusetts.

For more information—
Circle 81, inside back cover

Special Transformers of 5 va to 500 kva

A line of special and custom built air-cooled transformers and autotransformers is available, ranging in capacities from 5 va to 500 kva. These units are expected by their manufacturer to fill a special need where standard out-of-catalog transformers are inadequate or when large manufacturers cannot economically produce and furnish special types in small numbers.

These transformers may prove ap-

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Aluminum?
Stainless?
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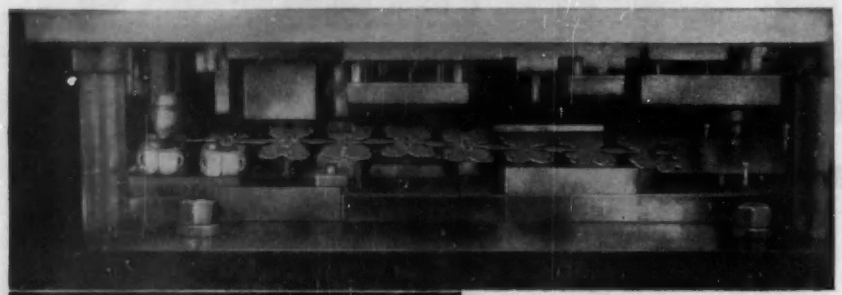
by B. Jahn add

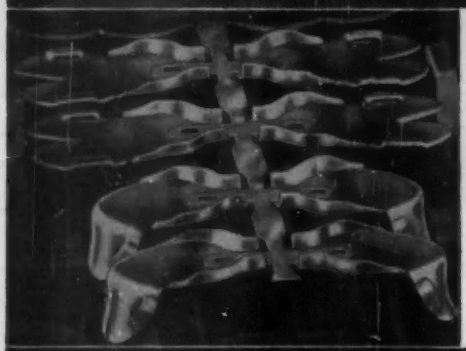
AUTOMATION TO YOUR PRODUCTION

TRANSFORM RAW STRIPS TO MICRO-TOLERANT COMPONENTS—OR COMPLETE ASSEMBLIES—IN SECONDS FLAT!

True Automation — piercing . . . forming . . . swaging . . . coining . . . blanking . . . and trimming — with no intermediate steps or inspection — is possible in one press operation with B. Jahn progressive dies. From raw material to finished piece, B. Jahn dies perform precisely, uniformly — cutting unit time and unit cost with every press stroke. Every B. Jahn die is skillfully engineered and built to afford progressive production in one operation — then "production proved" by actual use in the customer's equipment to guarantee that every benefit of Automation is inherent in the die — and that it meets every specified requirement of performance and satisfaction.

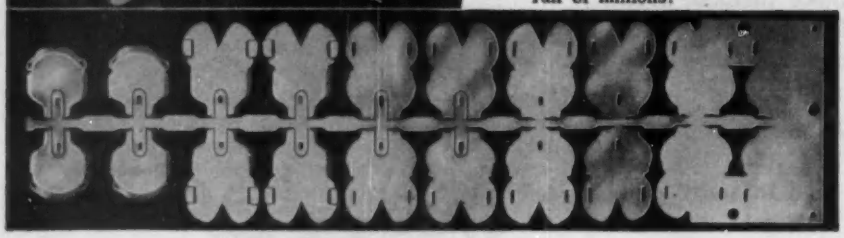
THIS OUTSTANDING EXAMPLE PROVES THAT B. JAHN PROGRESSIVE DIES AFFORD REAL AUTOMATION!





B. Jahn engineers were challenged to deliver a progressive die that would stand up and retain tolerances under the terrific forming shock required to make heel plates for roller skates from tough 17 gauge steel.

B. Jahn devised and built a 10 station progressive die that met every stringent forming and drawing requirement — operated at 70 strokes per minute — delivered 2 pieces per stroke — on a production run of millions!



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B. Jahn

THE B. JAHN MANUFACTURING COMPANY, NEW BRITAIN, CONNECTICUT

plicable in heating, welding, testing, lighting, controlling, phase changing, electronics, power supplies and other special applications. Mounted indoors, no additional fire protection is required. Multi-Amp Corp., 10 Third St., Newark 7, N. J.

For more information— Circle 82, inside back cover

Panel Meters

This meter is available in four types, all of which are housed in magnetically shielded unbreakable metal cases with scales said to be readable at 8 to 10 ft. Front zero adjustment is provided and 2 per cent accuracy is assured. Phaostron Co., 151 Pasadena Ave., S. Pasadena, Calif.

For more information— Circle 83, inside back cover

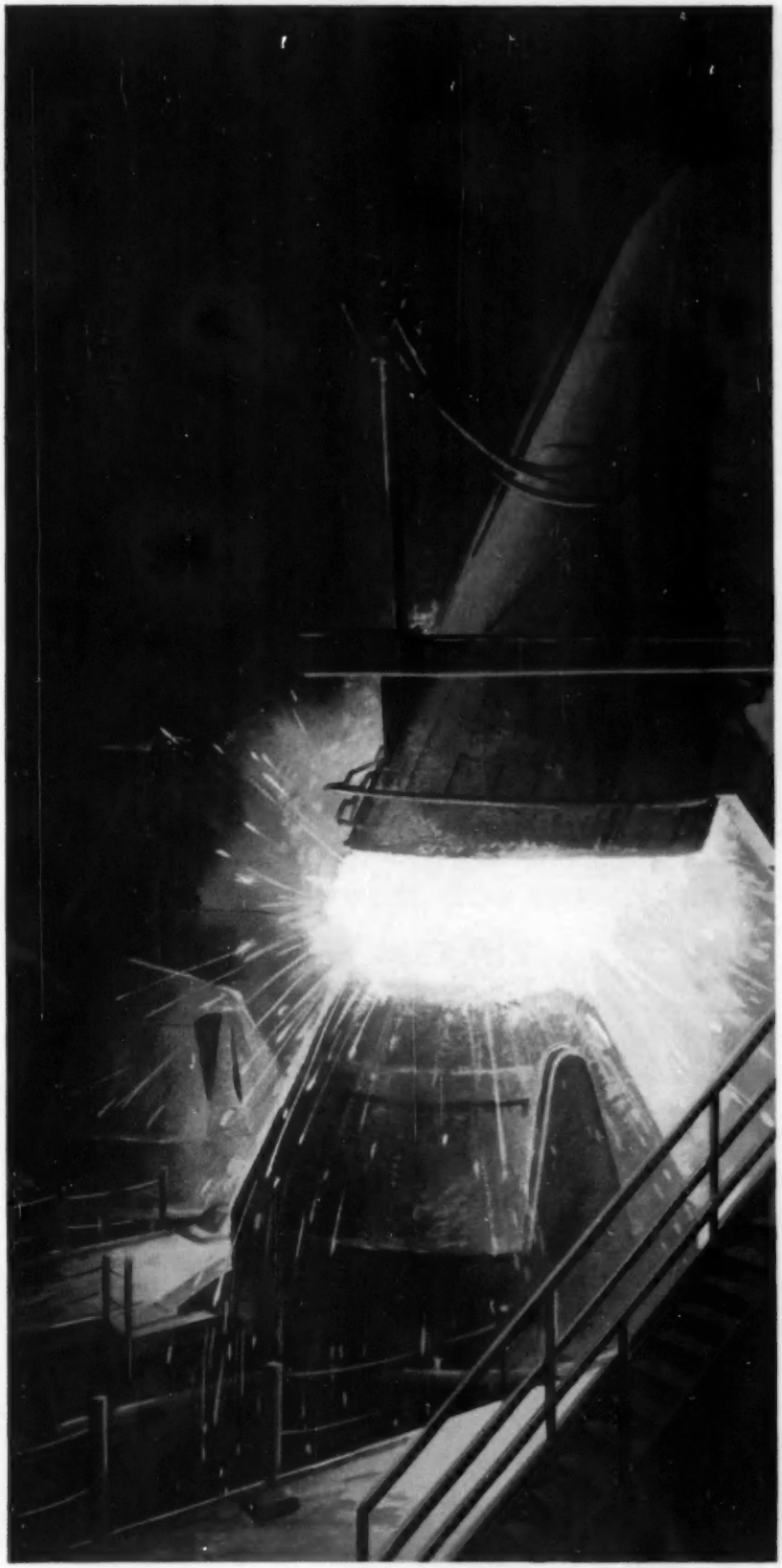
Blower Wheels

These blower wheels have forward curved blades and were designed for use in appliances such as room air conditioners, dryers, furnaces and oil burners. They are available in either steel or aluminum, in 18 diameters from 2-$\frac{7}{16}$ to 12-$\frac{3}{8}$ in., in single and double inlet types. Revcor Co., P. O. Box 25, Carpentersville, Ill.

For more information— Circle 84, inside back cover

Pulse Oscillator

This oscillator features a wide range of pulse spacing, from 0.3 microsecond (3.3 megacycle repetition rate) to 11,000 microsecond (90 cycle repetition rate), in five ranges. The basic oscillation period is set up by a specially designed multivibrator which has several feedback paths. Two output blocking oscillator pulses—either of which can be positive or negative—are available from the front panel,



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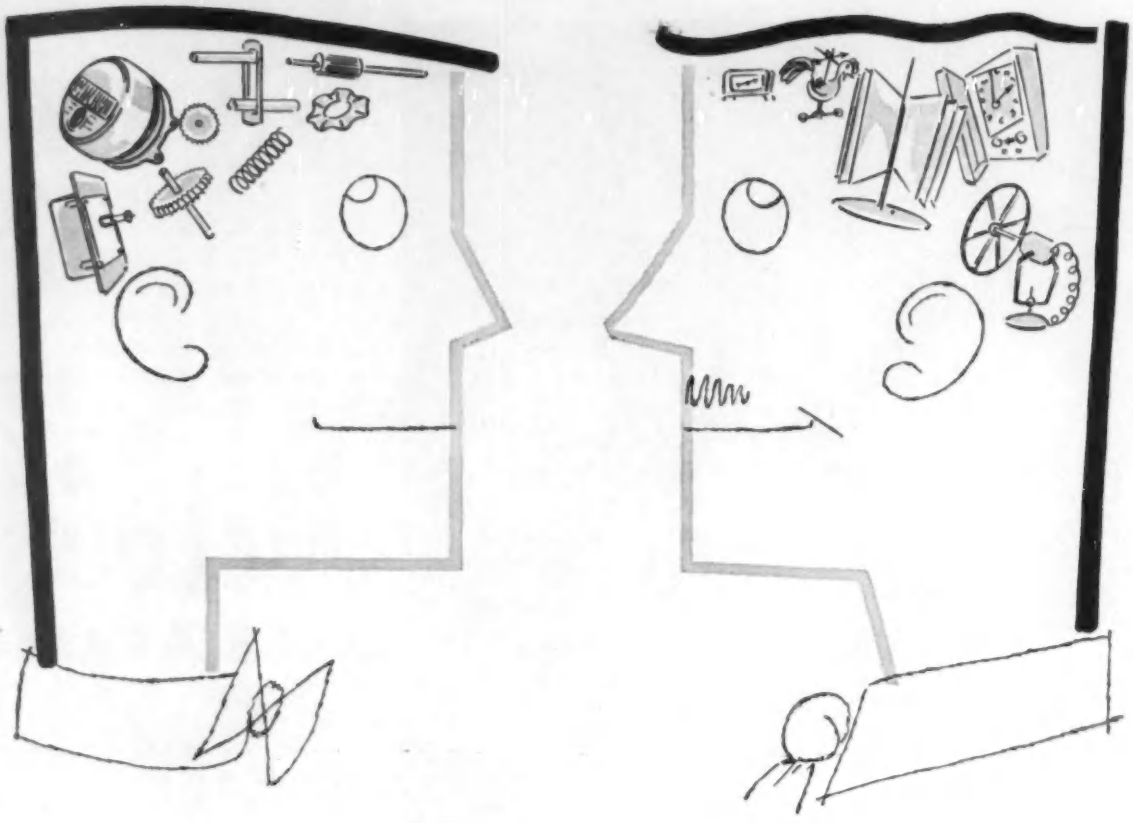
MANUFACTURERS OF STAINLESS AND CARBON STEELS



... it is in the product development stage
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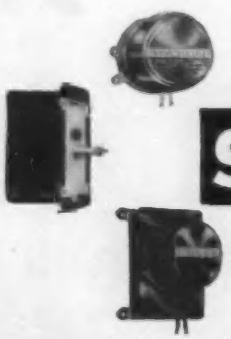
You are designing a machine to control a predetermined cycle of operation, or to accomplish some desired motion. To do the job effectively you need a timing motor of adequate power and dependable accuracy. Size, speed, torque, adaptability . . . all are important. And to get the best possible performance, your motor and machine must be engineered to work together, smoothly and efficiently.

Over the years, it has been our observation that the most successful timing devices have been the result of co-ordinated engineering between the machine designer and SYNCHRON motor engineers. It is a simple case of "you tell us" what is to be expected of our motors . . . the power required, the general nature of the job it is to do, the proposed method of mounting, whether the action of the machine is continuous or interrupted . . . and any peculiarities of performance that may be demanded of it.

Do this . . . and let our engineers submit their suggestions along with a sample motor. We may save you many costly manhours of research and test time. This service is free to any established organization of sound reputation and reliable rating. We suggest you contact your local SYNCHRON Representative, or address the factory. All development engineering is conducted in strictest confidence.

FACTORY REPRESENTATIVES

Wesley & Fromm, 5254 W. Madison St., Chicago, Ill.
R. H. Winslow & Associates, 123 E. 37th St., New York, N. Y.
Electric Motor Engineering, Inc., 8255 Beverly Blvd., Los Angeles, Cal.



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SYNCHRON SYNCHRONOUS MOTORS, TIMING MACHINES, CLOCK MOVEMENTS, AND MAGNA-TORC D.C. MOTORS

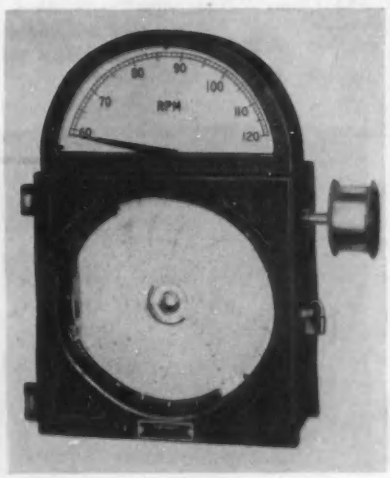
HANSEN MANUFACTURING CO., INC. PRINCETON 5, INDIANA

Established 1907

spaced by the half period of the multivibrator oscillator.

These pulses are 0.1 microsecond wide above 100 kc, and widen out to approximately 0.5 microsecond below 100 kc, with an impedance level of 250 ohm, or below, and with variable amplitude to 25 v, open circuit. Electro-Pulse, Inc., 11811 Major St., Culver City, Calif.

For more information—
Circle 85, inside back cover



Indicating and Recording Tachometer

This tachometer automatically records the operation of the machine on which it is installed. It also shows speed and every change in speed, starting and stopping times, slowdowns and non-productive periods, time and duration of each. Amthor Testing Instrument Co., Inc., 45 Van Sinderen Ave., Brooklyn 7, N. Y.

For more information—
Circle 86, inside back cover

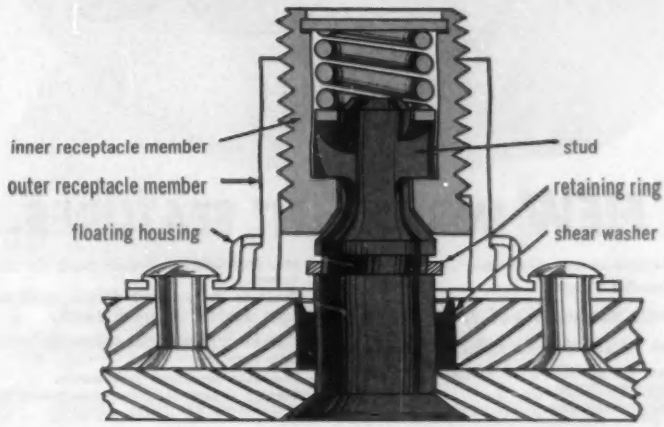
Miniature Axial Blowers

These blower units are powered by a new 1-in. dia motor. They are for spot cooling of electronic equipment

New High Performance Fastener

EXCEEDS ULTIMATE TENSILE and SHEAR LOADS OF NAS 547

New PANELOC High Performance Aircraft Fastener Carries Primary Structural Loads in Shear and Tension with Minimum Deflection and Minimum Sheet Separation.



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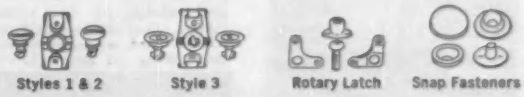

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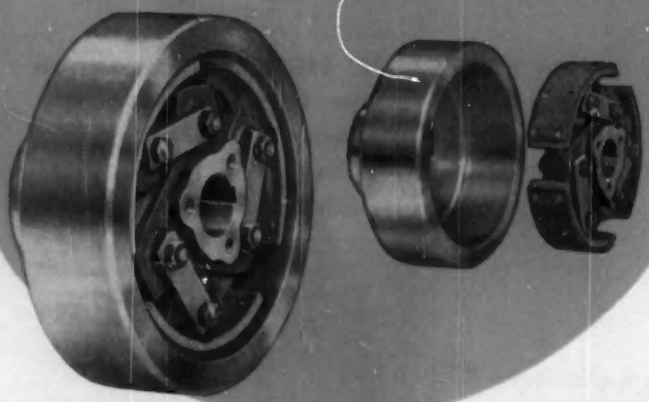
AUTOMATIC CENTRIFUGAL CLUTCH COUPLING



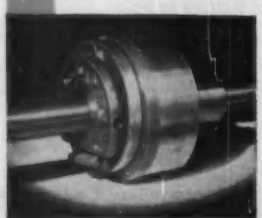
11 NEW IMPORTANT FEATURES..

1. Flexible in all directions.
2. Absorbs Shock.
3. Limits torsional vibration.
4. Has adjustable idle speed.
5. Can be furnished in automatic free-wheeling type.
6. Smooth starting.
7. No slip under normal load at full speed.
8. Protects driver and driven mechanisms against overload shock.
9. Can be furnished in automatic backstop type.
10. Prevents torsional resonance.
11. Easily assembled even in blind installations.

If you have problems of misalignment — smooth starting — vibration — overload — or assembly in the manufacture or operation of:

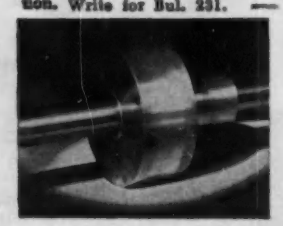
- Compressors
- Blowers
- Diesel Engines
- Excavators
- Refrigeration
- Hammer Mills
- Textile Machinery
- Wire Machines
- Fans
- Gasoline Engines
- Back Stop Brakes
- Mixers
- Conveyors
- Pumps
- Electric Motors
- Generators
- High Speed Pulverizers
- Tube Mills

• Let Our Engineers Consider Your Problem. Twiflex May Be The Answer.



SINGLE REVOLUTION CLUTCH
For automatic, accurate control, electrically or mechanically, of intermittent motion, indexing, cycling, cut-off Write for Bul. 239

OVER-RUNNING CLUTCH
For automatic engagement and release on two speed drives, dual drives and for ratchet feed or backstop action. Write for Bul. 231.



SLIP CLUTCH
For overload protection — constant torque — constant tension on reeling or winding stands. Write for Bul. 300

WRITE TODAY! For Details of TWIFLEX Coupling in Catalog CE-3

THE HILLIARD Corporation
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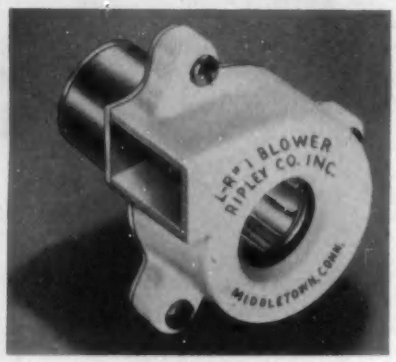
MANUFACTURING CLUTCHES FOR 50 YEARS

and for air changing in small, equipment-filled boxes.

These blowers have no brushes, and operate without arcing and without radio interference. At speeds of 11,000 and 20,000 rpm, standard 400-cps blowers produce 32 and 58 cfm (at 0 in. static pressure). Variable frequency 360 to 1600 cps units produce a minimum of about 25 cfm at 0 in. of static pressure. These blowers measure 2 in. dia and have an overall length of $3\frac{3}{8}$ in. Eastern Air Devices, Inc., 381 Central Ave., Dover, N. H.

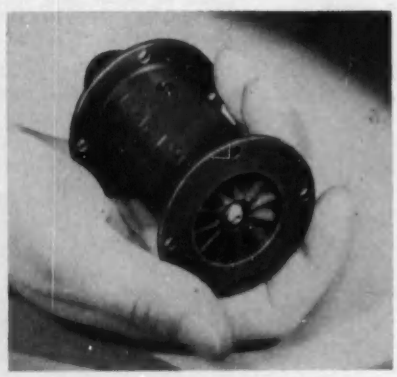
For more information— Circle 87, inside back cover



Sub-miniature Blower

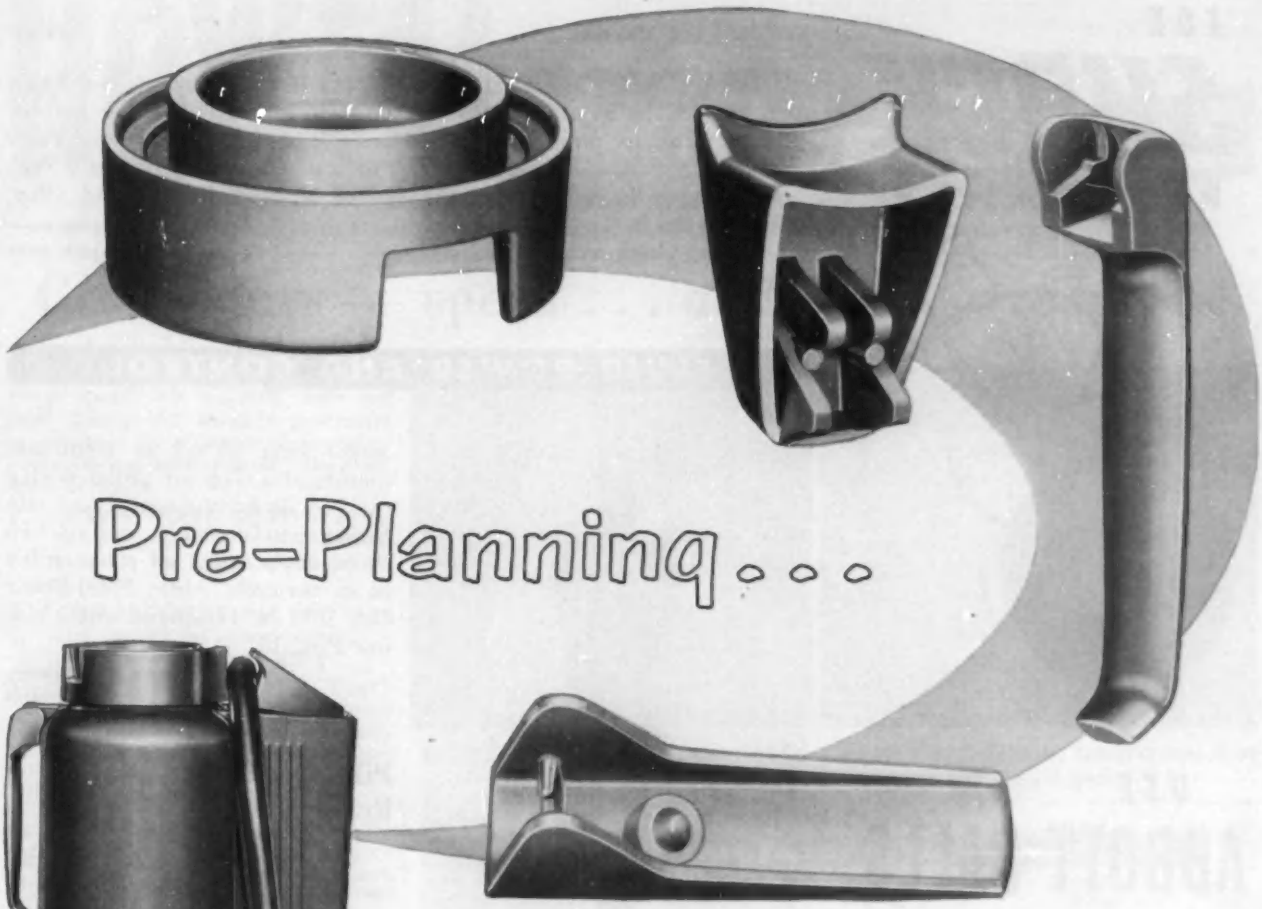
Using a 1 in. dia impeller, this unit will move 36.8 cfm at 20,000 rpm. Total weight is said to be less than $2\text{-}\frac{3}{4}$ oz. Designed to meet military specifications, it is available for both clockwise and counter-clockwise rotation. Ripley Co., Inc., Middletown, Connecticut.

For more information— Circle 88, inside back cover



Axial Flow Blowers

These blowers are being produced in standard sizes at rated capacities from 16 cfm to 750 cfm. They are



Pre-Planning . . .

Illustrating the Ansul Chemical Company's 10-pound dry chemical fire extinguisher. The group of four die castings was developed with the close cooperation of Ansul Engineers and Madison-Kipp Die Designers.

an important design phase with **MADISON-KIPP** *zinc and aluminum die castings*

In almost every product design cycle there is a pre-planning stage when major changes can be made with comparative ease. It is then that it is valuable to have in mind such things as parting line possibilities, metal entrance, machining control points, draft angles, etc.

Our customers of long standing usually send us their rough layouts for review because this pre-planning has proved to be important in advancing time schedules and in establishing economies of manufacture.

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When the ability to "take it" is a factor in the selection of bearing balls, be sure to ask for Abbott — "the ball with the Armored Heart".

Cold forged from selected carbon steel wire, every Abbott Ball is DEEP HARDENED and TEMPERED. This gives it extra stamina to perform efficiently under high load factors and withstand jarring shocks.

Abbott Balls are unsurpassed for sphericity, size tolerance and other essentials of fine carbon steel bearing balls.

Specify Abbott . . . you can't ask for a better ball.

The ABBOTT BALL CO.

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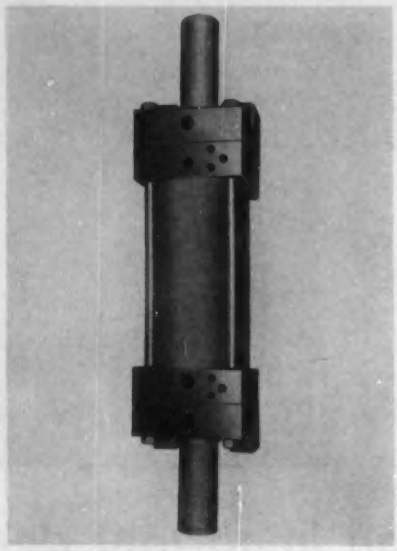
Hartford 10, Conn.

self-contained units incorporating a rotor coupled to an electric motor, either dc or ac, for precise control of air volumes.

According to the manufacturer, the smallest model in the line is a 1-¾-in. dia blower, which weighs 8 oz and delivers 16 cfm. Other units will vary up to 16 in. dia and will be available as single or multi-stage blowers. Pesco Products Div., Borg-Warner Corp., 24700 N. Miles Rd., Bedford, Ohio.

For more information—
Circle 89, inside back cover

FLUID POWER AND CONTROL



Reciprocating Air-Hydraulic Booster

A continuous-action, automatically reciprocating booster said to be capable of delivering an unlimited amount of high pressure fluid for the operation of hydraulic cylinders has been announced. This booster operates from ordinary plant compressor air input. It consists of a double-rod end air cylinder with a hydraulic discharge pressure chamber at each end. Thus, it delivers a pressure output stroke in both directions.

At the end of each stroke, the piston assembly contracts an actuator button on the inside of the cylinder. The movement of this button operates the actuator which, in turn, shifts the position of a four-way, two-position, double pilot-operated valve causing reversal of air flow and corresponding reversal of booster stroke.

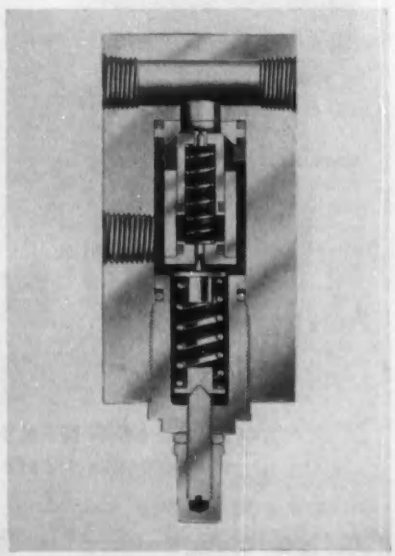
It is available in all ratios to give pressures to 10,000 psi and over. The reciprocating booster is being stocked for immediate delivery in 25:1 ratio units that produce 2000 psi hydraulic output from 80 psi air input and consists of a 5-in. air piston driving two 1 in. dia hydraulic rams, each ram having a stroke of 6 in., and a 4.7 cu in. oil displacement per stroke or 9.4 cu in. per cycle. Miller Fluid Power Co., 2040 N. Hawthorne Ave., Melrose Park, Ill.

For more information—
Circle 90, inside back cover

Pilot-Operated Relief Valve

A piston type pilot-operated relief valve maintains pressure in hydraulic systems between 50 and 4000 psi. Maximum hydraulic pressure is maintained at a constant level in the system. If the system pressure approaches the pre-set relief pressure, oil bleeds into the pilot valve chamber through a small orifice. Should the pressure in the system reach the relief setting, the pilot valve vents to tank, permitting the system pressure to unseat the main valve, with high flow relief to tank.

This series of valves is made with



HOWELL MOTOR BRIEFS

Quick facts for those who design-in and specify electric motors

Gearmotors — speed . . . *and cost* . . . reducers!

Where driven speeds less than normal motor speeds are required, there are good reasons for using a gearmotor as opposed to a motor-plus-reducer-plus-coupling arrangement. Here are some of them:

1. **LOWER FIRST COST** is a big advantage—see table in adjoining columns for some specific comparisons.
2. **COMPACTNESS** that can give you significant space savings — plus a *better looking* drive.
3. **STANDARDIZATION** — fewer parts for you and your customers to stock. NEMA-standard gearmotors, like Howell's, are completely interchangeable — Howell ships them from stock.
4. **GREATER RELIABILITY** — With one integral unit and direct coupling, chances for wear and failure are greatly reduced.

Gear Hardness Counts

The degree of compactness and reliability you get in a gearmotor is dependent in good measure upon the hardness of the gears. Howell's parallel shaft units have gears machined to close tolerances from steel substantially harder (Rockwell 52-60) than is average in the industry. Result — a smaller gear package with superior wear resistance. Howell right angle units have precision ground steel worms integral with shaft, and worm gears made of high grade alloy bronze.

The right angle type of gearmotor is a recent addition to the Howell Motor line and complements the parallel shaft series. A Howell sales engineer will be glad to show you which is best for your application.

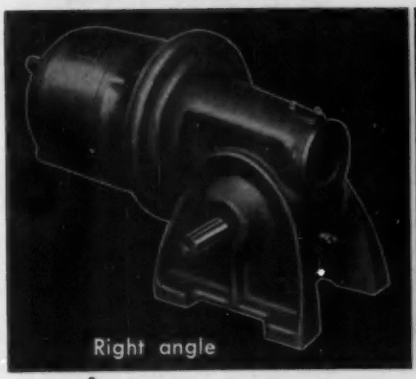
Note This Versatility

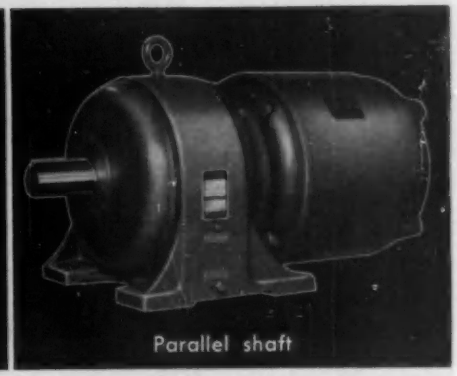
Howell is one of the few manufacturers to offer gearmotors with the motor of any electrical or mechanical type. Electrical types available include elevator and hoist, slip ring, torque and multi-speed motors.

Mechanically, they can be supplied in various types of enclosures — either with feet or with flanges for mounting horizontally or vertically. Optional accessory equipment includes brakes and zero speed switches.

see our catalog in S or write for copy

Howell Gearmotor Capacities:
Parallel Shaft: 1 to 150 hp
Right Angle Shaft: ⅛ to 40 hp


Right angle


Parallel shaft

***savings*— Howell Gearmotors vs. Separate Motor, Reducer, Coupling and Base — based on open motor and Class I gears**

I. Ratio 11.4 to 1 or 155 RPM with 1750 Motor

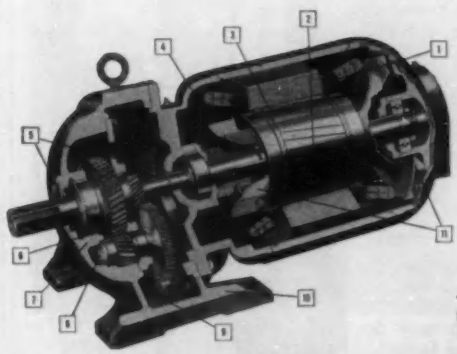
HORSEPOWER	GEARMOTOR SIZE	REDUCER SIZE	GEARMOTOR SAVINGS*
1	21A-203	21-SL	$106.76
1½	21A-204	21-SL	82.38
2	21A-224	21-SL	60.12
3	21A-225	21-SL	28.32
5	21A-254	22-SL	35.52
7½	23A-284	23-SL	101.10
10	23A-324	23-SL	52.70

II. Ratio 86.5 to 1 or 20 RPM with 1750 Motor

1	32A-203	32-SL	$ 71.30
1½	33A-204	33-SL	134.08
2	33A-224	33-SL	78.96
3	34A-225	34-SL	154.42
5	34A-254	34-SL	43.06
7½	35A-284	35-SL	236.80
10	35A-324	35-SL	111.40

*Complete cost breakdown furnished on request

11 reasons why Howell Gearmotors last longer, serve you better



1. High-quality insulation
2. Copper-clad rotor
3. Expert Craftsmanship
4. High-quality coil varnish
5. Leakproof oil seals
6. Duti-Rated Lifetime Gearing
7. Unit case construction with integral bearing housings
8. Corner-mounted offset shaft
9. Large oil reservoir
10. Heavy, cast-iron construction
11. Superior cooling

Write for Bulletin GM-1

HOWELL Red Band MOTORS

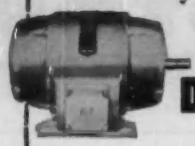
HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

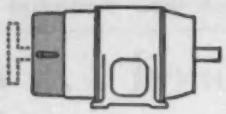
PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

exclusive
REULAND
"Xpandable" design

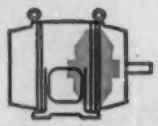
typical adaptations from this **BASIC DESIGN**



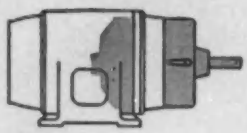
combines motors • brakes fluid couplings • gear-reducers into tailor-made single-unit POWER PACKAGES!



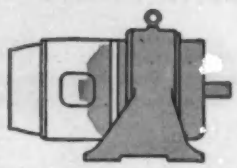
Motor with Reuland "Through Shaft" magnetic brake



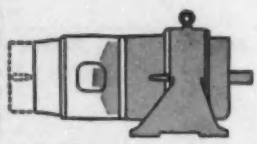
Motor with internal fluid coupling



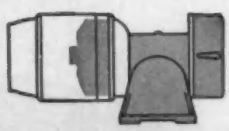
Motor with fluid coupling and brake on output shaft



Motor with fluid coupling and helical gear reducer



Motor with fluid coupling, output shaft brake and helical gear reducer (second brake may also be added)



Motor with fluid coupling, right-angle worm reducer and brake

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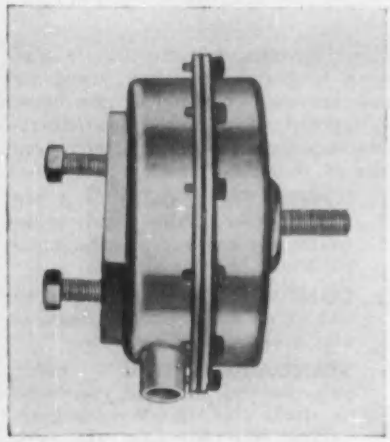
female pipe connections, sizes ¼ to 2 in., in aluminum alloy or semi-steel. There are three pressure ranges: 50 to 100 psi; 1000 to 2500; and 2500 to 4000 psi. Republic Mfg. Co., 15655 Bookpark Road, Cleveland 11, Ohio.

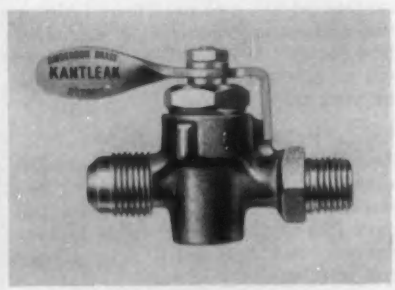
For more information— Circle 91, inside back cover



Pneumatic Air Chambers

These air chambers are designed for use where space is limited. Only 3 in. needed from bottom to top of push rod. They have a ¾ in. stroke with a maximum force of either 228 or 1000 lb at 100 psi air pressure. They come in two styles, bottom or clevis mount. They are recommended by their maker for holding or clamping of parts for welding, riveting, drilling or assembly operations. Horton Mfg. Co., 1179-15 Ave., S.E., Minneapolis 14, Minnesota.

For more information— Circle 92, inside back cover



Manual Shut-Off Valve

The valve is constructed with a solid button and a spring-loaded packed top, eliminating the possibility of leakage. The exterior 90 deg stops insure positive accuracy of fluid control in the open and closed positions.

The 370C Series is UL-listed and is available on the following end combinations: ¼ and ⅜ in. male and/or female pipe thread. Anderson Brass Co., 5303-12 St., Detroit 8, Mich.

For more information—
Circle 93, inside back cover

Miniature Control Valve

This 6-in. high, automatic diaphragm valve weighs 3¼ lb. It will provide low hysteresis and instantaneous response on service up to 1000 psi at 350 F over a 3 to 15 psi control air range. All materials and construction consistent with control valve specifications, including stainless steel and Teflon. Direct or reverse action, top mounted positioners and handjacks are available. The valve has five sizes of linear, equal percentage or quick opening plugs, ⅞ in. and below. George W. Dahl Co., 430 High St., Bristol, R. I.

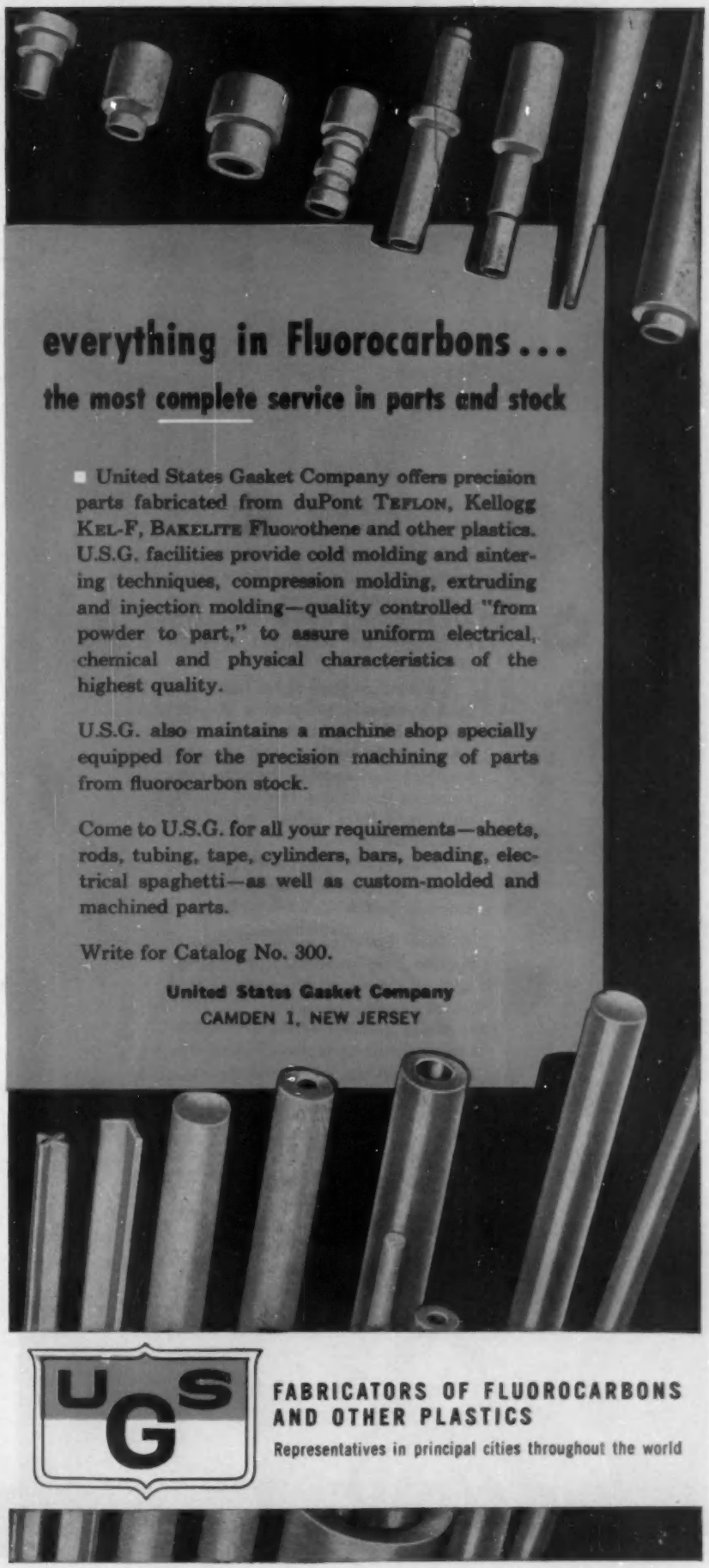
For more information—
Circle 94. inside back cover

High Pressure Corrosion Resistant Valve

This valve was designed primarily as a control valve for acid distribution lines. It is suited for use in flow lines carrying any type of corrosive liquid under high pressure. Capable of withstanding pressures up to 1000 psi, the valve is made of a nonporous Saran plastic enclosed in a stainless steel jacket. The valve tip is also made of Saran plastic. This insures liquids flowing through the line will not be contaminated by coming in contact with metal.

A synthetic rubber O-ring seals the valve stem. This O-ring can be removed or replaced without taking the valve out of the system.

Valve stem blowout is said to be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New Bedford, Massachusetts

Address all communications to 768 Belleville Ave., New Bedford, Mass.

prevented and it is impossible to remove the stem by opening it too far. The valve is currently available in two standard sizes with the ports tapped for either ⅜ or ½ in. standard metal or plastic pipe. Exline Engineering Co., 1636 E. 6 St., Tulsa, Okla.

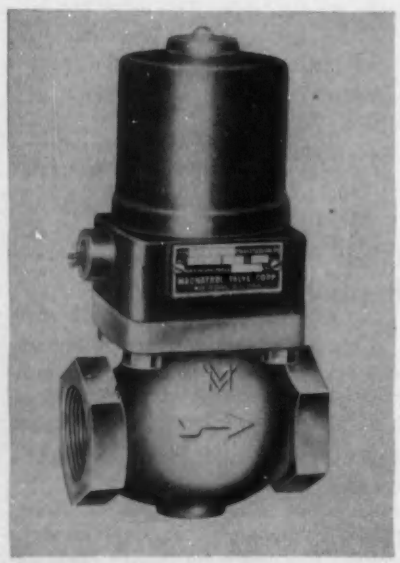
For more information—
Circle 95, inside back cover

Adjustable Flow Regulator

This flow regulator for air, water, oil or gas is primarily designed for pneumatic tools and equipment, paint spray guns or similar devices. It can also be used as a shut-off valve.

It holds up to 1500 pound pressure without leaking. Simple rotation of the outside knurled sleeve provides flow control or regulation. Eight adjustment points are provided for one revolution of the regulating sleeve. Each adjustment increases or decreases the orifice or opening 0.004 in. The regulator weighs 4 oz. Burklyn Co., 3429 Glendale Blvd., Los Angeles 39, California.

For more information—
Circle 96, inside back cover



Packless Solenoid Valve

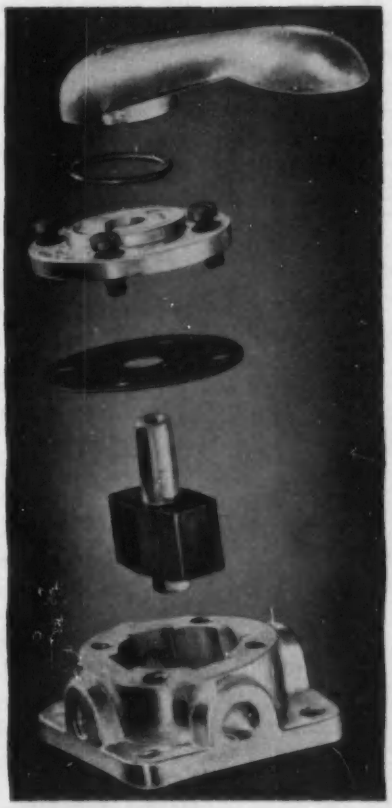
A solenoid that uses line pressure to assist the solenoid in opening and closing the valve is designed for normally closed operation and provides a full port equal to the nominal pipe size opening. The valve may be applied to control automatically or from

remote points the flow of steam, hot liquids and gases not injurious to bronze, at fluid temperatures up to 400 F.

An auxiliary operating piston, that is integral with the disc holders, assists the solenoid in opening the valve against higher line pressures. At low or no pressure the solenoid alone will actuate the valve. The pilot valve is stainless steel and the valve is single-seated and closed by a resilient disc suitable for higher temperature service.

The valve body is of the globe pattern, has screwed ends and is available in sizes from ¼ to 3 in., cast in bronze. Valve can be supplied with either handlift or handlever for manual control, or with metering stem for throttling the flow. Magnatrol Valve Corp., Hawthorne, N. J.

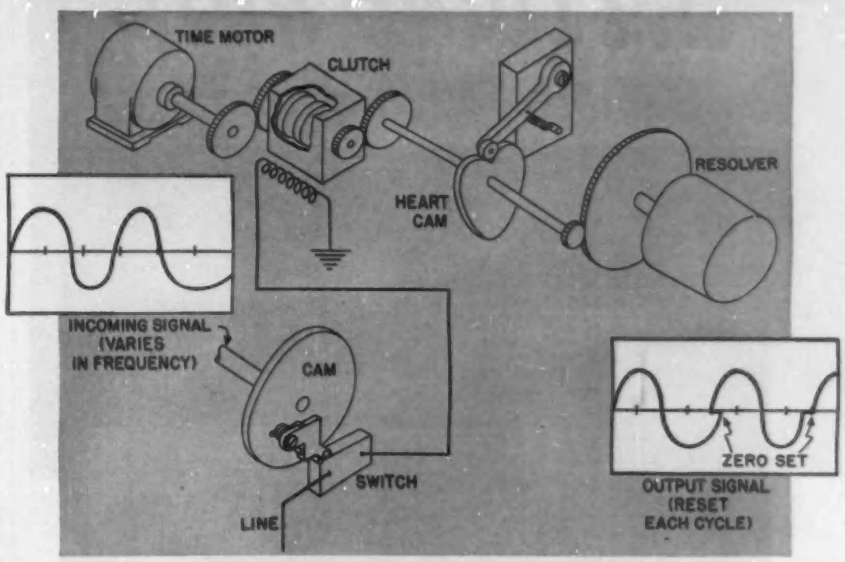
For more information—
Circle 97, inside back cover



Four-Way Rotary Air Valve

This valve is a hand-operated, three-position type and has a rubber rotor bonded to the shaft. There is no metal-to-metal contact, for instead of holes passing over ports, the rubber

SINCE 1915 LEADERS IN AUTOMATIC CONTROL



HOW TO ZERO-SET RANDOM PHASE VARIATIONS

Many modern control devices are designed for applications where sensed input signals fluctuate randomly about an approximately known frequency. In some of these applications, the information is conveyed by the phase relationship within one cycle, and the random cycle-to-cycle phase variations often submerge the signal in noise. Filtering, or averaging, techniques may be extremely difficult to devise because of the requirement for use within one cycle.

The ingenious electro-mechanical solution shown above is a typical Ford answer to a difficult problem. It is rugged and reliable, yet compact and easy to service. In operation, a constant-speed motor drives a resolver at the required speed. The sensed input controls the operation of the clutch, and at each zero-crossing in the positive direction, decouples the motor from the line. At the same time, the spring-loaded heart cam follower resets the synchro shaft to its zero position.

In this manner, the resolver is reset to a prescribed phase relative to the signal at a fixed point of every cycle of the generated signal.

This is another instance of how Ford's engineering staff selects the most efficient device to solve a problem. Here at Ford mechanical *and* electronic devices are given consideration in solving any problem.

Since 1915 the engineers at Ford Instrument Company have specialized in such equipment as computers, controls, and servo-mechanisms in hydraulics, electronics, mechanics and magnetics for the Armed Forces and for industry. If you have problems in any of these fields, it will pay you to discuss them with Ford engineers.

67

FORD INSTRUMENT COMPANY
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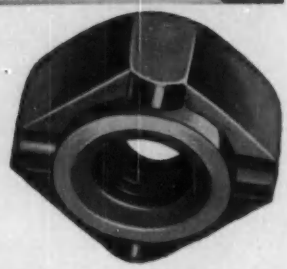

If you've got a product involving metal fabricating, fastening or assembling, chances are you can use Midland Welding Nuts to big advantage.

They come in all sizes for every-sized job. Welded to the part or parts concerned, they don't have to be held while bolts are turned into them. Thus one man can often do the work of two.

And they're indispensable when it comes to those tucked away, hard-to-get-at places. Welded in advance to those inside spots where it is difficult—or *impossible*—for hands or tools to reach, Midland Welding Nuts hold fast while bolts are turned into them.

If you're a designer, you'll want to know about these time and labor-savers, too. Midland Welding Nuts will solve and simplify many of *your* problems, too.

Write or phone for complete information!

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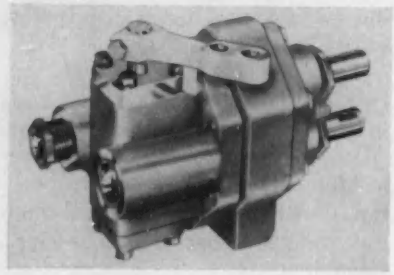
Air and Electro-Pneumatic Door Controls

rotor passes over rounded surfaces. Available in ¼ and ⅜-in. sizes, the valve is a cadmium-plated die casting and permits variable throttling with air pressures up to 150 psi. Mechanical Air Controls, Inc., 10030 Capital, Oak Park, Detroit 37, Mich.

For more information—
Circle 98, inside back cover



Three-way Valve and Pump

A hydraulically balanced, plug-type three-way valve and pump is now available in single or double shaft models. It is rated for 1000 psi duty, and can handle up to 2000 psi overload and 3000 psi shock load.

The SY series is available in five sizes, developing from 8 to 22 gpm at 1000 rpm, 1000 psi. The unit is reversible, providing rotation in either direction. Wisconsin Hydraulics, Inc., 3165 N. 30 St., Milwaukee 15, Wis.

For more information—
Circle 99, inside back cover

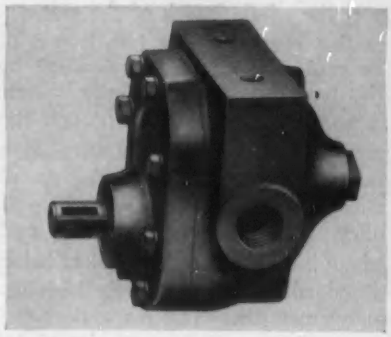
Filters, Oils and Regulates

Water accumulates to a predetermined level in this unit's filter bowl, then drains into the float valve-equipped lower bowl. When it reaches sufficient depth, valve opens to discharge excess water; ¼ in. female connection is provided for drain piping. Sufficient water level is maintained in both bowls to provide a constant seal against air leaks. Modernair Corp., 400 Preda St., San Leandro, Calif.

For more information—
Circle 100, inside back cover

Hydraulic Gear Pump

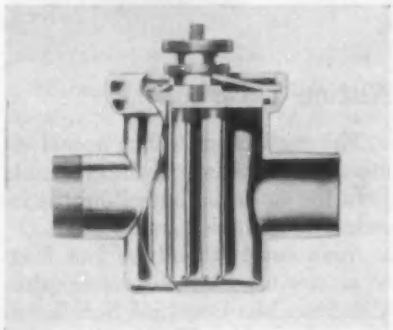
These pumps have a pressure loading on their bearings that is said to raise volumetric efficiencies as high as 97 per cent. Fluid pressure from the



outlet side is exerted on the pump bearings to maintain the end clearance between gear and bearing faces at a thin film of oil. Wear is reduced and the pump lasts longer. There is automatic compensation for any wear that does occur.

Three different capacities are available: 10, 12 and 16 gpm, with speeds of 2000, 2000 and 2200 rpm and displacements of 1.32, 1.56 and 1.93 cu in. respectively. Each of the three models may be equipped for base, round flange or magneto flange mounting. In addition, each unit features keyed shaft, side ports and assembly for rotation in either direction. Pesco Products Div., Borg-Warner Corporation, 24700 North Miles Road, Bedford, Ohio.

For more information—
Circle 101, inside back cover



Magnetic Pipeline Traps

These non-electric permanent magnet traps are made in two models, to fit pipelines from ½ to 4 in., and in a range of materials, finishes and strengths adapted to a variety of operating conditions and problems. Made in Type 316 stainless steel the unit is available for 2, 3 or 4 in. pipelines.

Multiple magnetic elements, contained in stainless steel tubes, are so positioned within the trap that material is caused to flow in thin streams, and in variously changed directions,

Can You Check YES to these five questions?

- ☐ Do the gears you use have surface-hardened teeth?
- ☐ Are the cores tough, ductile, and shock-resistant?
- ☐ Do they always fit perfectly and require no run-in?
- ☐ Are they guaranteed to give maximum service life?
- ☐ Are you completely satisfied with them?

If not, you should use—

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ARMORED GEARS are made only by PITTSBURGH GEAR from an exclusive formula perfected by PITTSBURGH engineers. It covers metal, machining, and a method of heat-treating that hardens the wearing surfaces but leaves the core tough, ductile, and shock-resistant.

All PITTSBURGH gears are made to extremely close tolerances to fit perfectly right from the start. They are guaranteed to give you five times the life of untreated gears, one to one and one-half the life of oil-treated gears, and equal or longer life than any other gear in identical service.

You can readily identify **Armored Gears** by their distinctive corrosion preventive coating—"**Pittsburgh Purple**."

You'll save money if you use PITTSBURGH **Armored Gears**. Send your specifications to us today. We'll quote promptly on one or any quantity of gears you need.

SPUR
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HELICAL
HERRINGBONE
WORM GEARS
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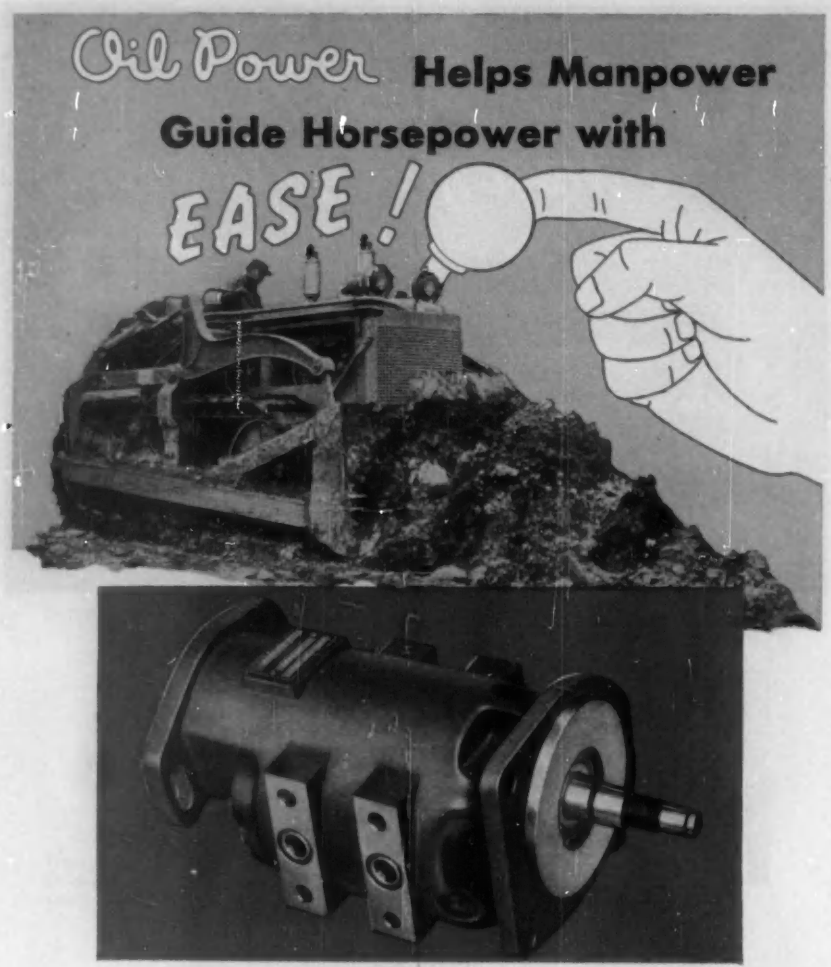
Neville Island
Pittsburgh 25, Pa.
Phone: SPaulding 1-4600

subsidiary of BRAD FOOTE GEAR WORKS, INC. • CICERO 50, ILLINOIS



Arm-weary tractor operators are grateful for TD-14A and TD-18A International Harvester crawlers. They steer with the ease of a late model car for each track is controlled by its own hydraulic circuit...a booster system with velvet smooth, positive action that stems from

HYDRECO
Oil Power

Here is a HYDRECO dual pump that delivers 5 gpm to each circuit at 1200 rpm against a system pressure of 700 psi. The dual pump provides a circuit for each track and the result . . . no arm-weary operators . . . more accomplished with less effort, in less time . . . smoother, higher performance . . . lower maintenance.

For engineers seeking practical answers to problems of trouble-free hydraulic controls, better performance, added functions and greater sales appeal for mobile equipment, the experience of HYDRECO engineers offers a definite answer!

WRITE— *for latest literature and full information on new developments in HYDRECO Pumps, Motors, Valves, and Cylinders.*

HYDRECO DIVISION
THE NEW YORK AIR BRAKE COMPANY
1112 EAST 222nd STREET • CLEVELAND 17 • OHIO
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

over the whole length of the magnets so that even very fine iron is said to be readily captured and retained by the powerful magnetic fields. There is no restriction of flow through the trap; in operation, iron accumulation tends to work around to the downstream side of the tubes where it offers no interference to flow, and where it is doubly secure against being dislodged even by relatively high velocity materials. The magnetic tubes are mounted as an integral part of the cover, hence are removable for cleaning by simply loosening the closure and withdrawing the entire assembly. Eriez Mfg. Co., Erie 6, Pa.

For more information—
Circle 102, inside back cover

Airline Lubricator

This airline lubricator is said to atomize the oil in a chamber remote from the air line. Only oil mist is injected into the air stream.

Any volume of air, from ¾ cu ft up to air line capacity can be lubricated. Gits Bros. Mfg Co., 1866 S. Kilbourn Ave., Chicago 23, Ill.

For more information—
Circle 103, inside back cover

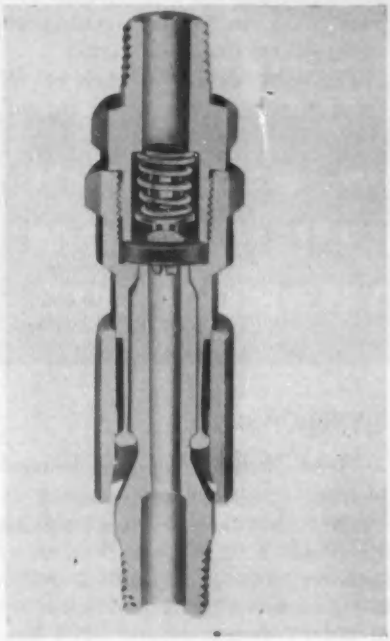
Automatic Air Filter

This air filter is operated by the differences in pressures caused by the flow of air through its several chambers. As air flows through, water and all foreign substances with a specific gravity greater than air collect in the main filter chamber of the unit. Upon the sudden stoppage of this air flow, an internal valve changes position.

During this period, the full line pressure purges through the opening at the bottom of the separator all collected water and foreign substances.

The new filter operates on all air pressures from 20 to 175 lb. Weight is 1¾ lb. Overall size, 2½ x 3½ x 3¾ in. high. Engman Mfg. Co., 1317-1319 Locust St., Des Moines, Iowa.

For more information—
Circle 104, inside back cover



Swiveling Coupling

Stock couplings are immediately available in single valve-type construction with various styles of threaded ends and hose attachments to choose from. Double-valve and straight-thru couplers are available on special order. The collet principle of this coupling has also been used successfully on vaporproof electrical connections, rod ends and flexible shaft applications with excellent results. R. S. Corcoran Co., P.O. Box 1404, Joliet, Ill.

For more information—
Circle 105, inside back cover

Bulk Refill Filter

Covers of these filters are fastened by swing bolts which, when loosened, swing down and release cover. Smaller covers can be removed by one man.

Nine different sizes are provided to meet the needs of the small machine tool as well as of a central system.

DUDCO PRESENTS . . .

for MOBILE EQUIPMENT

a New Dual-Vane Pump

SERIES PFM-100

2000 psi Continuous Duty

3 to 11 gpm at 1200 rpm 0 psi

TWO VANES ARE BETTER THAN ONE

The hydraulically counterbalanced DUAL-VANES in DUDCO Hydraulic Pumps eliminate wear producing loads normally caused by unbalanced hydraulic forces and vane acceleration. DUAL-VANES also maintain MULTIPLE SEALING BARRIERS to slippage and power loss. DUAL-VANES are a patented and exclusive DUDCO feature.

This Pump was engineered to meet the special conditions characteristic of service on mobile equipment.

Here is a pump designed for high speed direct engine drive that can be operated *continuously* at *2000* psi and *2000* rpm to meet the continuing demand for more work from your equipment.

The exclusive DUDCO Dual-Vane design provides and assures *complete hydraulic balance* of all internal parts. Bearing loads and cam ring wear are reduced so DUDCO PFM-100 Pumps last longer.

Designing these Pumps into your machines is made easier because all standard S.A.E. or industrial mountings and piping provisions are available, as well as complete flexibility of port positions.

PFM-100 Series Pumps are priced for the competitive mobile equipment market . . . NO price penalty for high pressure equipment.

Write — for complete information on the new DUDCO PFM-100 Series DUAL-VANE Hydraulic Pump.

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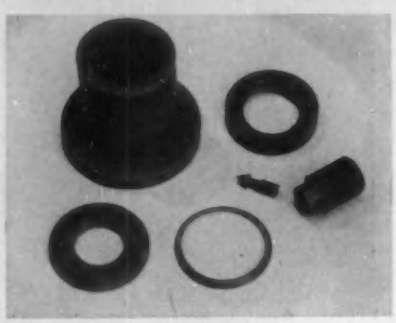
A choice of electric, steam or hot water heat is available.

Interchangeable bulk refills of absorbent Fuller's earth or inert cellulose fiber are used to filter a wide range of industrial oils including engine lube oils, hydraulic oils, turbine oils, quench oils and roll oils. Houdaille-Hershey of Indiana, Inc., 210 Superior Ave., Lebanon, Ind.

For more information—
Circle 106, inside back cover

ENGINEERING MATERIALS



Plastic Rod of Chlorinated Polymer

Mechanical properties of this material are generally good at room and boiling temperatures. At 73 F, tensile strength is 6,000 psi. It is both harder and lighter than the fluorocarbon materials currently available. Machinability of the material is said to be excellent.

The new material is available for prompt delivery in rods up to 2 in. dia for machining. Larger diameter rods and other shapes such as strip, slabs and tubing will be offered in the future. Polymer Corp. of Pennsylvania, Reading, Pa.

For more information—
Circle 107, inside back cover

Insulation Also Controls Condensation

A new pipe insulation which combines maximum insulating efficiency and condensation protection for lines operating at low temperatures or at alternating cycles of high and low temperatures, ranging from −120 F to 250 F, has been announced. The pipe insulation is made of fibrous glass bonded with a thermosetting binder and the jacket is composed of a five-ply laminate including an asphalted kraft paper for the inner surface, a bleached kraft paper on the outer surface, the two enclosing an 0.001 in. thickness of aluminum foil. This jacket has a vapor transmission rating of less than 0.01 perm.

The pipe insulation will fit all standard sizes of pipe to 33 in. and copper tubing to 6 in. The pipe insulation, fastened in place with metal bands, is available in nominal thicknesses of 1, 1½, 2 and 2½ in. Owens-Corning Fiberglas Corporation, Toledo 1, Ohio.

For more information—
Circle 108, inside back cover

Sponge Vinyls

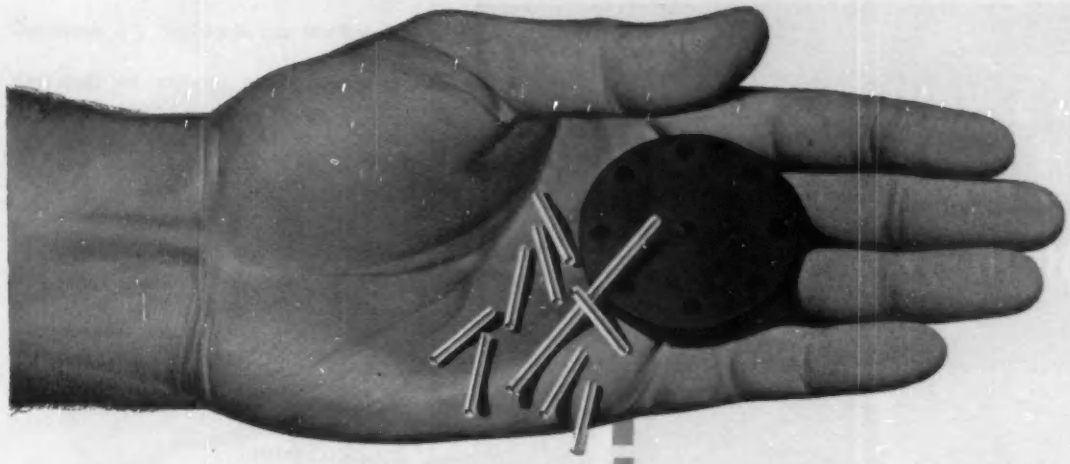
These plastisols contain chemical blowing agents and are shipped as liquids. When subjected to 300 to 400 F for 3 to 30 min, these compounds produce a uniform vinyl sponge. Temperature and time required for fusion depend upon size and mass of the object and the cross-section of the sponge. The expansion rate can be controlled by the compounder to provide plasisols which will expand 100 to 600 per cent and provide densities from 8 to 30 lb per cu. ft.

This series of sponge vinyl plasisols may be used in the manufacture of rollers, arm rests, gaskets, toys, crash pads, sheeting, cushions, upholstery backing, rug backing, packing, insulation, boots, socks, shock absorbers and other items. Watson-Standard Co., 223 Galveston Ave., Pittsburgh 12, Pennsylvania.

For more information—
Circle 109, inside back cover

Roll-Formed Tube

The pressure butt or closure effected in this tube is said to eliminate the costly swaging process usually employed to close the longitudinal seam of the tube. The butt is accomplished



PAY LESS FOR MORE RUGGED

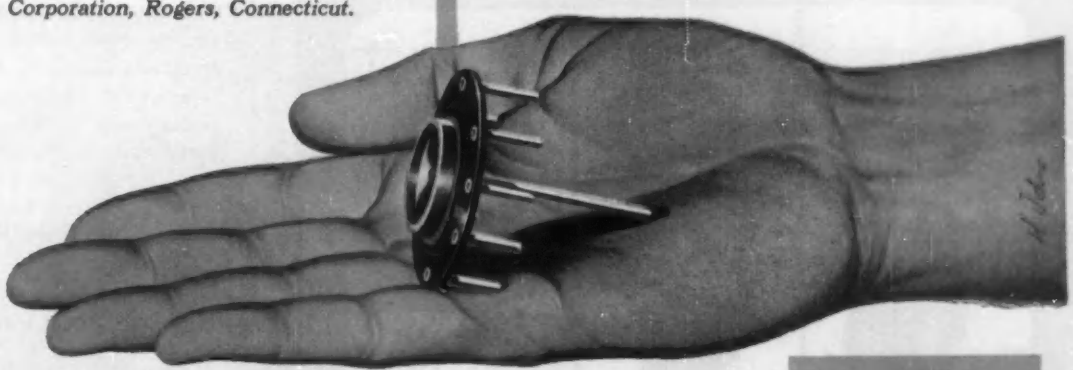
PLASTICS WITH MOLDED-IN METAL COMPONENTS

USE ROGERS PHENOLIC SHEET MOLDING MATERIALS

Three series of Rogers phenolic *sheet* molding materials are available: RM 9275, a cellulose-filled grade with an impact strength of 1.8; RM 4000 grades, glass-cellulose reinforced, with impact strengths ranging from 4.0 to 7.0; and RM 2035, an electrical grade, designed when properly molded to meet electrical standards equivalent to NEMA XXXP laminate. *Please write for data sheets to Dept. E, Rogers Corporation, Rogers, Connecticut.*

MAKE THIS COMPARISON AND SEE WHY

ROGERS PHENOLIC SHEET MOLDING MATERIALS	CONVENTIONAL HIGH IMPACT PHENOLICS
Low bulk factor of 1½ to 1	High bulk factor of 10 or 12 to 1
Low cost shallow molds	Expensive deep molds
Preforms can be blanked and pre-drilled for accurate location with inserts	Volumetric loading or hand preforming makes for difficulty in locating material with inserts
Preforms blanked from sheets of uniform thickness form mold charges of exact weight	Mold charges difficult to measure — require exact weighing to avoid over- or under-charging
Fast, uniform preheating	Slower, less uniform preheating
Good to excellent moldability	Poor to fair moldability
Low tooling cost, simplified production molding, minimum rejects, low unit parts cost	High tooling cost, tricky, expensive molding operations, high reject rate, high unit parts cost



ROGERS CORPORATION

ROGERS, CONNECTICUT

PRODUCTS

DUROIDS—for Gaskets, Filters, Electronic Devices, etc.
SHOE MATERIALS—for Counters, Midsoles, Liners, etc.
ELECTRICAL INSULATION—for Motors, Transformers, Generators, etc.
PLASTICS—Special Purpose Molding Compounds and Laminates.

SERVICES

FABRICATING—including Combining, Coating, and Embossing.
DEVELOPMENT—Research and Engineering of New Materials, Parts, and Products.

what's your small motor problem?

☐ Economy?
☐ Dependability?
☐ Quiet operation?

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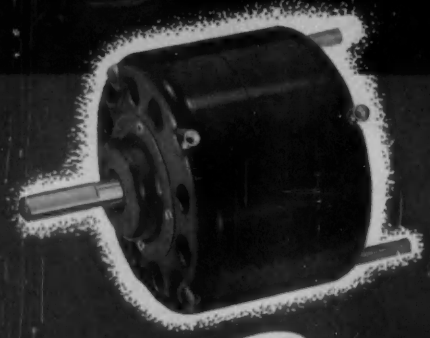
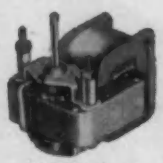


GT Smooth Power MOTOR

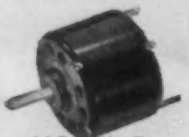
Depend on famous GT know-how to produce the right motor to fit your exact needs. Just name your problem. If one of the basic models listed below isn't readily adaptable to your product, GT's engineering department is at your service to help you design a special motor for any specific application. Our complete and modern facilities — backed by over 25 years' experience in solving the motor problems of large and small users throughout the world — are your guarantee of satisfaction. Call or write today for consultation without obligation.

MODEL A
2-pole, shaded pole AC Induction Type

MODEL E
4-pole, shaded pole AC Induction Type



MODEL F
2-pole, shaded pole AC Induction Type



MODEL B
4-pole, 4-coil shaded pole AC Induction Type

MODEL D
4-pole, 4-coil shaded pole AC Induction Type

NOT SHOWN:
MODEL C — 2-pole, shaded pole AC Induction Type
MODEL O — 2-pole Capacitor Reversible Type, AC only (for 6, 12 or 24 volts)

Write for Complete Motor Catalog

THE GENERAL INDUSTRIES CO.
DEPARTMENT GM • ELYRIA, OHIO

in the forming process, by directing the metal stresses to counteract each other and close the seam. In normal butt seam tubing, pressures tend to spread the seam.

The result is reported to be a straighter and stronger tube that resists torque. Acme Tube Corp., 212 Coit St., Irvington, N. J.

For more information— Circle 110, inside back cover

Plastic Steel

Said to resist shrinking or expanding out of shape, a machinable mixture of 80 per cent steel powder and 20 per cent plastic resin is now available that can be used to make prototypes and models of new products, and for certain types of jigs, molds, fixtures and dies. Chemical Development Corp., Danvers, Mass.

For more information— Circle 111, inside back cover

Tempered Beryllium Copper Wire

A heat treatment and cold work process is said to be resulting in a beryllium copper wire having an ultimate tensile strength of 185,000 psi, and yet ductile enough to wrap around its own diameter. Further heat treatment of finished parts made from this wire is reported to be unnecessary. It can be formed into springs, wire rope and complex shapes. It is non-magnetic, has excellent fatigue qualities and comes with a silver plating which allows easy soldering. Little Falls Alloys, Inc., 189 Caldwell Ave., Paterson, N. J.

For more information— Circle 112, inside back cover

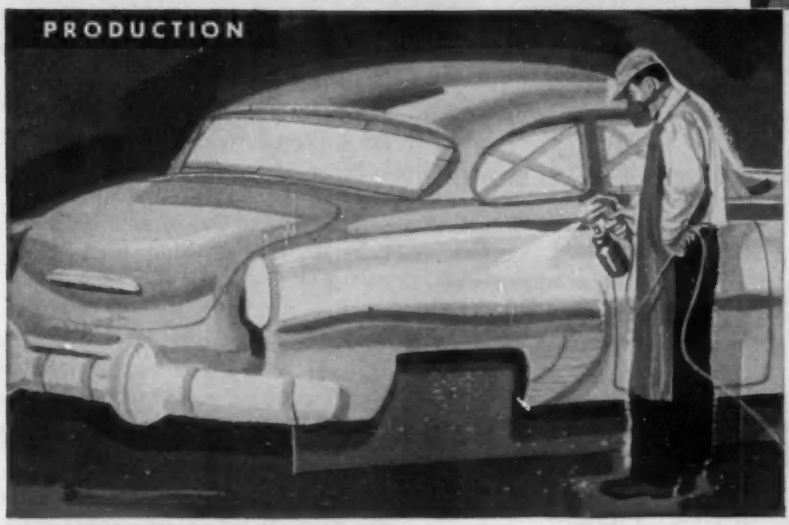
Sheet Rubber Packing

This line of packing material is made by a process which is designed to cure rubber continuously. Packing made this way is said to be more uniformly cured, providing greater stability, smoother finish.

The new packing is used as flange gasket material for air, hot or cold water, saturated steam and hydraulic services. It is also used for bumpers, mounting pads and many general

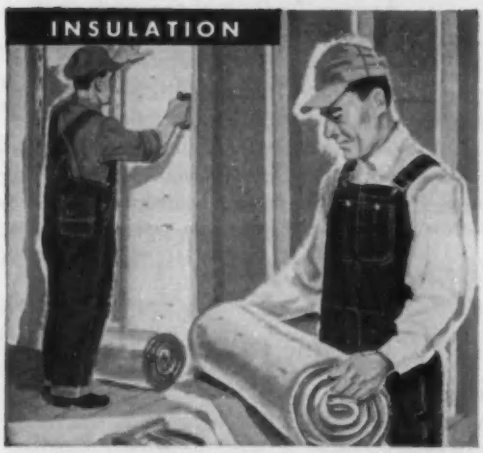
Is there a way to do it better - with paper?

Here are paper applications Mosinee helped develop for three industries — Good tip: they may suggest new uses for you!



Mosinee interleaving papers protect mirror-finish stainless steel. The presence of any foreign materials or surface imperfections would mar or scratch the metal's highly polished surface. Mosinee, through highly developed chemical and quality controls, produces these special papers with the required uniform properties.

Special Mosinee masking papers increase auto painting efficiency, reduce costs. These papers must have specific, controlled physical properties including high density and absolute freedom from pin holes to prevent paint penetration. Mosinee "know how" helped develop papers for this special application.



Flame-resistant paper by Mosinee makes good insulation better — safer. In this case, Mosinee flame-resistant paper is produced for the manufacture of home insulation bats. This exclusive Mosinee process may also be used with many types of paper for other products and may suggest a solution to your problem.

THESE applications are typical of the many instances in which Mosinee paper experts have cooperated with industry to develop special analysis papers to perform specific jobs. If your work involves costly or troublesome packaging . . . protection . . . insulation . . . lamination . . . fabricating . . . or processing — a specialized Mosinee paper may provide the answer you've been looking for.

For details on how to do the job better with papers by Mosinee, see your representative, or write —

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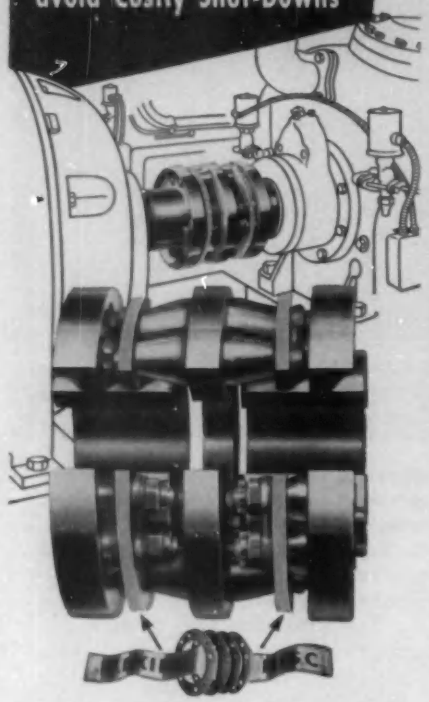
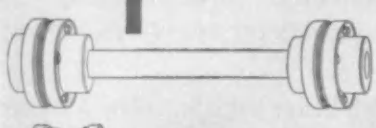
Specify THOMAS ALL METAL FLEXIBLE COUPLINGS for Power Transmission to avoid Costly Shut-Downs

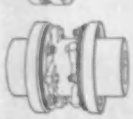


Patented Flexible Disc Rings of special steel transmit the power and provide for parallel and angular misalignment as well as free end float.

DISTINCTIVE ADVANTAGES

FACTS	EXPLANATION
NO MAINTENANCE	Requires No Attention. Visual Inspection While Operating.
NO LUBRICATION	No Wearing Parts. Freedom from Shut-downs.
NO BACKLASH	No Loose Parts. All Parts Solidly Bolted.
CAN NOT "CREATE" THRUST	Free End Float under Load and Misalignment. No Rubbing Action to cause Axial Movement.
PERMANENT TORSIONAL CHARACTERISTICS	Drives Like a Solid Coupling. Elastic Constant Does Not Change. Original Balance is Maintained.





Thomas Couplings are made for a wide range of speeds, horsepower, shaft sizes and can be assembled or disassembled without disturbing the connected machines, except in rare instances.

Write for new Engineering Catalog No. 51A

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

gasket service applications. Available thicknesses are from $\frac{1}{16}$ through 2 in., widths from 36 to 72 in. Boston Woven Hose & Rubber Co., Box 1071, Boston 3, Mass.

For more information—
Circle 113, inside back cover

Laminate for Printed Circuits

This epoxy resin, paper-base laminate is available in sheets only, natural color, $\frac{1}{16}$ to $\frac{1}{2}$ in. thick. Glass fiber-base sheets are also available. Copper-cladding is provided on special order.

Tensile strength is in the range 17,500 psi, flexural strength, 24,600 psi, impact strength, 0.56. All figures are for length-wise specimens.

For 0.1272 in. thickness, dry, dissipation factor is 0.0096, and dielectric constant, 4.77. After 24 hr immersion in water, a 0.1261-in. thick sample had a dissipation factor of 0.0633 and a dielectric constant of 5.19. American Printed Circuits Co., P. O. Box 282, Metuchen, N. J.

For more information—
Circle 114, inside back cover

Moisture-Proof Containers

Containers made of a variety of metallic materials are available that are equipped with a mechanical sealing arrangement to maintain any given humidity level. No dessicants are required and periodic checks of the condition of the stored materials is said to be unnecessary. The container, which can be of a wide range of sizes, can be opened and reclosed without the seal's barrier properties being lost.

Materials stored in this type of containers are customarily inserted ready for use. No greasing, waxing or other types of coatings are required. At present, cylindrical containers are regularly supplied. Rectangular types are under development. A built-in hygrometer is available if desired. While these new containers have seen mainly military service so far, they are expected to find application in industry for sensitive instrument mechanisms, controls and machinery, both in storage and in service. Lavoie Laboratories, Inc., Morganville, N. J.

For more information—
Circle 115, inside back cover

ENGINEERING EQUIPMENT

Magnifying Glass 2 in. Dia.

This magnifier has an aluminum frame and is $\frac{3}{4}$ in. thick. It magnifies curved, round or straight-line subjects five times. S. B. Logan & Co., P. O. Box 498, Genoa City, Wis.

For more information—
Circle 116, inside back cover

Makes Reproductions Up to 46 in. Wide

This machine is equipped with a 4,000-w quartz exposure lamp and reproduces prints up to 46 in wide by any length at a speed range of 14 in. to 40 fpm. Available as optional equipment are an adjustable, multiple-belt print delivery for front stacking of various size prints, a motor-driven rewinder for rolling up long prints in the rear, special guide rollers for stacking returned tracing and other originals in the front of the machine.

The unit is equipped with a fully synchronized electronic drive. The machine requires 200-230 v, single-phase, 60 cps, a-c current. The machine measures 68¾ x 58 x 71½ in. high. Charles Bruning Co., Inc., 4700 Montrose Ave., Chicago 41, Ill.

For more information—
Circle 117, inside back cover

Portable Drafting Machine

This model is for sheets up to 12 x 18 in. The machine takes detachable scales, available for either mechanical drawing or architectural work. The 15 x 20 in. tempered Masonite board has three paper clamps. The hinged mounting bracket of the parallel mechanism is provided with thumb screw adjustment for maximum freedom of action. The detachable pro-

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PROBLEM-FREE INSTALLATION and OPERATION!

Model 93

Because Copyflex reproduction machines are completely free from fumes and odors, they require no exhaust venting . . . they need no plumbing or auxiliary equipment, no installation other than an electrical connection.

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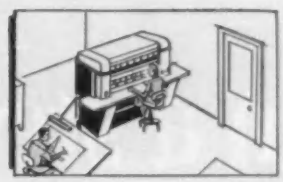

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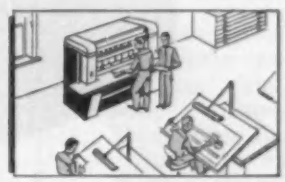
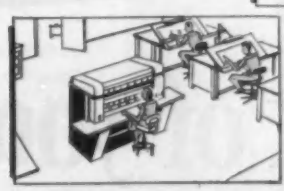
Near an inside wall—
no plumbing, no ducts!

PUT IT THERE . . .
Near an outside wall—
no vents in walls, windows!





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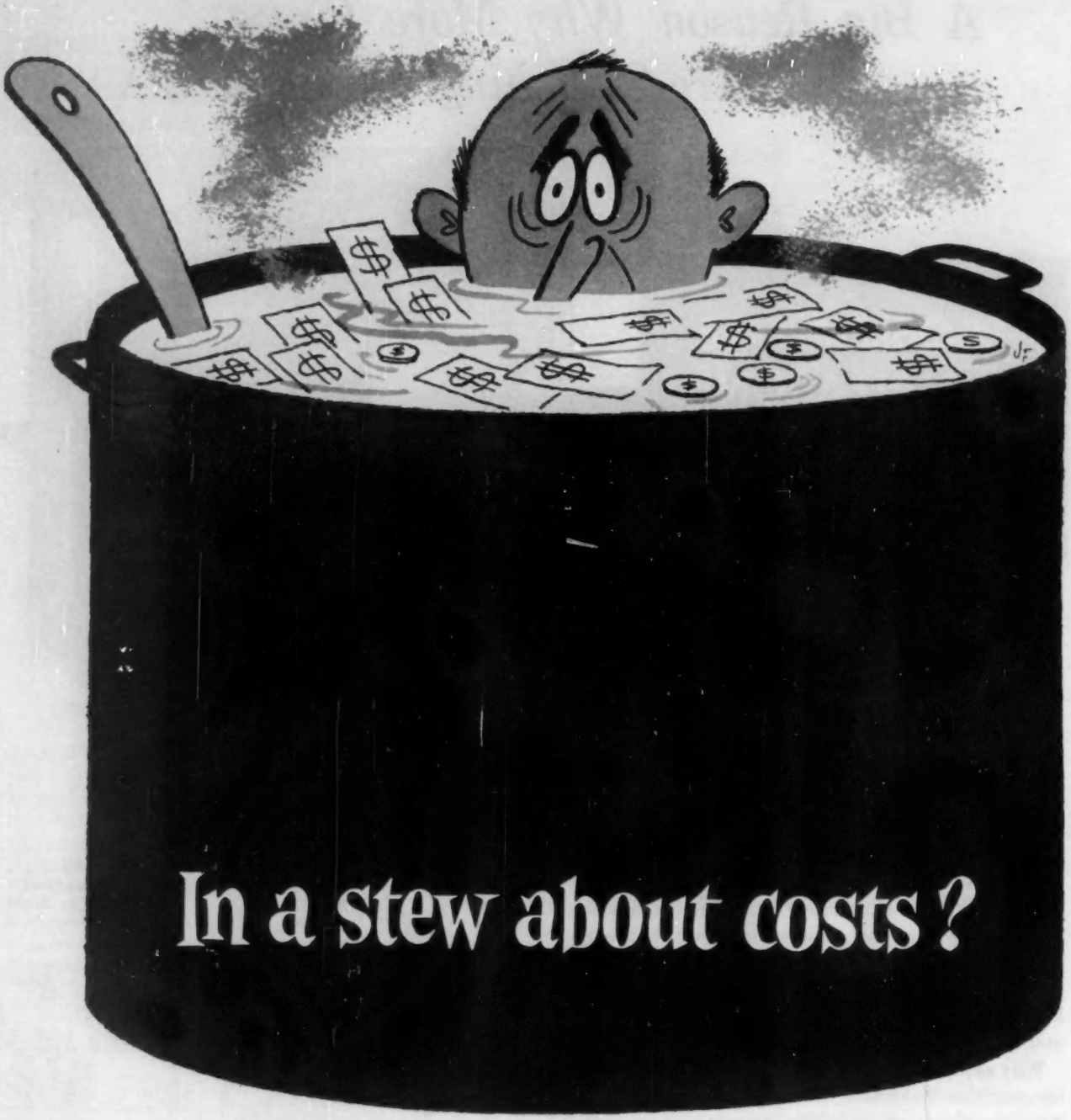

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YOUR Kaiser Aluminum Distributor can *cut* your unnecessary raw material outlay . . . *cut* your handling, insurance and depreciation costs . . . *raise* your production profits.

He can do all this if you use his warehouse as your own! He carries a wide variety of aluminum: almost any size, shape or alloy—slit, sawed or sheared. By using his supplies, you can cut down your own stock, increase your working capital and reduce your carrying costs. Profit-robbing storage space can be converted into room for production.

And his services don't stop there! He's geared to meet your emergency needs the minute you call. Because of his wide experience in the metals field he can specify the exact type of aluminum your product requires. He can suggest methods of using aluminum more economically. He can supply you with small quantities for experimental work.

All these services mean more profits for you because they lower your costs. Take advantage of the *personalized service* offered by your Kaiser Aluminum Distributor. Call him today!

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DAVENPORT, IOWA, Phone: 3-1895
Nichols Wire & Aluminum Co.
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Eureka Metals Supply Co., Mutual 7286
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Fullerton Metals Co.
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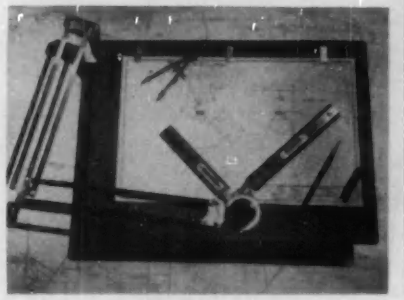
WICHITA, KANSAS, Amhurst 7-1208—7-1209
General Metals, Inc.



tractor is graduated to 2 deg for 180 deg, reading 90 deg each side of zero. Drafting Equipment Co., 504 Randolph St., Meadville, Pa.

For more information—
Circle 118, inside back cover

Ink In a Squeeze Bottle

Pin point applicator is said to prevent spilling or drying out and to give just the right amount of ink. Makes it possible to use all the ink, up to the last drop. Ink is electropolarized so no shaking is necessary. Carter's Ink Co., 239 First St., Boston, Massachusetts.

For more information—
Circle 119, inside back cover

Recording Oscillograph

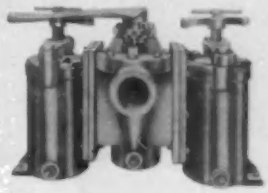
This oscillograph has all automatic operating controls on a front panel. Available in two models, the unit's record magazines, which can be loaded in daylight, are designed to handle a variety of recording film or paper ranging up to 12 in. widths. One model has a maximum of 36 channels and handles record widths to 8 in. Another model has a maximum of 60 channels and handles records to 12 in. Record magazines, galvanometer area and damping panel are accessible from the front of the oscillograph.

Record speeds for the new series range from ½ in. to 144 in. per sec. Four instantly selectable recording

• SINCE 1926 • in the application, design and mfg. of pumps — separators — hydraulic accessories.

KRAISSL

Simplex & Duplex SEPARATORS



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STRAINERS • FILTERS • STANDARD AND HIGH PRESSURE

ELIMINATE LIFTING JACKS

Kraissl Class 72 duplex separators are designed so that you don't need to use a lifting jack to raise the rotary plug valve. The valves are designed to a sufficiently wide angle taper — so that the plug does not wedge on its seat, through wear and use.

Grit, scale and extraneous abrasive matter settle on the seat face, from using a lifting jack. Then, when the plug is returned to its seat and the valve rotated, the seat is galled and scored. This terminates the serviceable life of your separators —and skyrockets your maintenance and overhaul costs.

Complete range of sizes—from 1¼" to 6"; pressures to 500 psi. Cast-iron, bronze, steel, stainless-steel, also aluminum, monel or special metals to your specifications.

Bulletin A-1214 gives full data —write for your copy today!

KRAISSL KRAISSL CO. Inc.

289 Williams Ave., Hackensack, N. J.

USE
DETROIT
DIE SET
DIE SET NO. OR STYLE SSD-2
DIE SPACE "A" 45" "B" 30"
THICKNESS OF SHOE "C" 3"
THICKNESS OF PUNCH "D" 3"
DIA. OF SHANK NO shank
LENGTH OF PIN 12"
STYLE OF BUSH
PREC. OR COM'L Precision
JOB NO. 5-1044
How to get the type of bushings you want in your die sets
Best way to get the quality die sets you want plus the type of bushing and pin assembly you prefer is to stamp "USE DETROIT DIE SET" on your blueprints. For here, along with a full-value die set, you have a choice of a dozen different bushing assemblies. For instance, the new self-oiling bushings that automatically lubricate friction surfaces. And then such types as ball-bearing assemblies, Lamina bronze-plated bushings with or without clamps, and solid Ampco bronze bushings with Alemite fittings.
For precision die work, specify a precision Detroit Die Set with the type of bushing that answers your specific needs.
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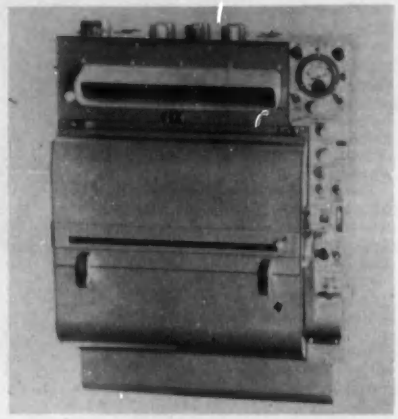

speeds are available from the front panel without interrupting the instrument operation and with simultaneous adjustment of recording intensity. A total of 48 steps and 24 separate speeds may be obtained by the manual changing of gears. No tools are required for these adjustments. Heiland Division, Minneapolis-Honeywell Regulator Company, Denver, Colorado.

For more information—
Circle 120, inside back cover

Instrument Components Kit

Consisting of 630 different parts such as gears, shafts, differentials, breadboard plates, hangers, bearings, this kit has all parts necessary for mechanical or electronic design problems. Material is designed for reuse. It is contained in a leather carrying case 5 x 12 x 18 . This new instrument components kit is complete with tools. Pic Design Corp., 160 Atlantic Ave., Lynbrook, N. Y.

For more information—
Circle 121, inside back cover

Measures Vibration

This meter measures the voltage generated by pickups attached to the objects or surfaces being tested. It gives quantitative information in terms of amplitude, velocity and acceleration.

The unit has connections for the input of four pickups, each measured separately by use of a selector switch. A jack permits connecting the signals to recording equipment or oscilloscope. Furnished with filters, the meter cuts off low frequency vibrations from the overall vibration spec-

trum thereby simplifying analysis work.

The meter operates from 117v, ac, weighs 14 lb, is $6\frac{7}{8}$ x $12\frac{3}{8}$ x $8\frac{3}{4}$ in. MB Mfg. Co., 1060 State St., New Haven 11, Conn.

For more information—
Circle 122, inside back cover

Sensitized Film For Whiteprint Process

A reproducible film which is said to block ultra-violet light more effectively than "lith" types of photographic film is diazo-sensitized (for ammonia development).

Symbols, letters, numbers, design components, cartoons have been successfully printed on this new film from translucent originals, cut out and then taped on clear cellulose-acetate or Mylar film to form efficient printing-masters. Tecnifax Corp., Holyoke, Mass.

For more information—
Circle 123, inside back cover

Pressure Transducer Laboratory

This instrument is cylindrical, with a circular sensitive area of $\frac{9}{16}$ in. dia at one end and a miniature coaxial connector at the other. It employs a piezoelectric ceramic transducer, and is constructed for general use. Its low electrical side is insulated from

Spincraft did it for AMF . . .

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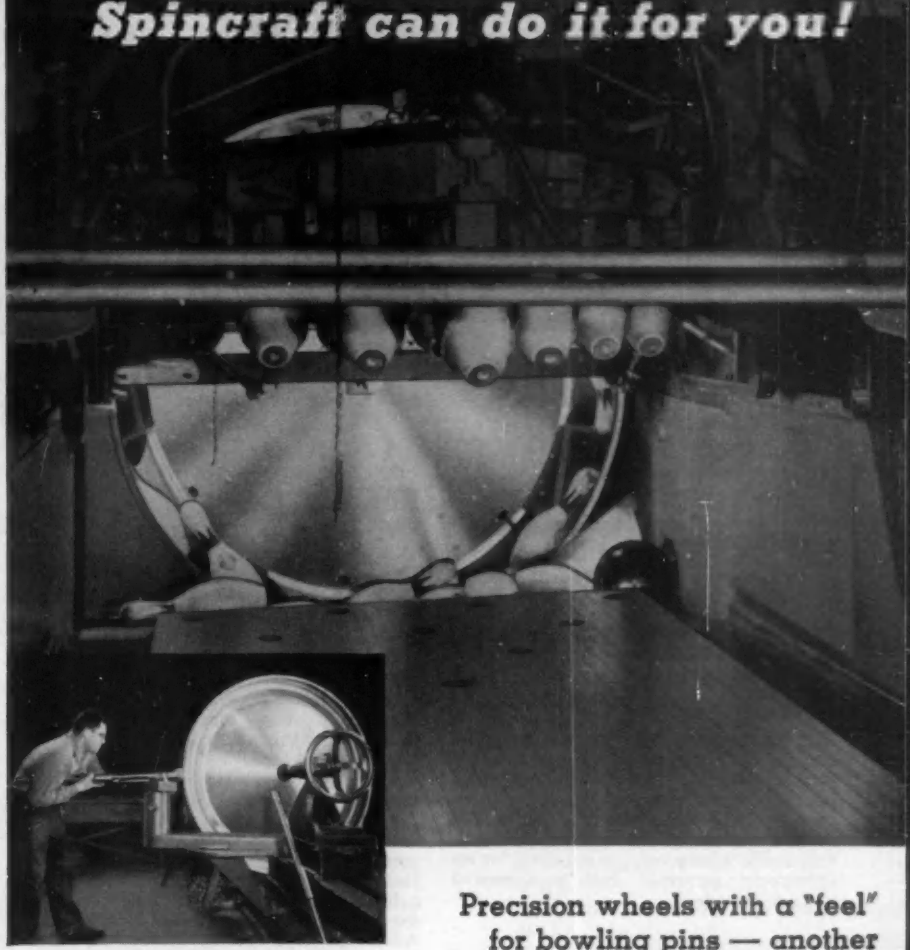
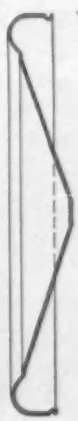


NINE DIFFERENT OPERATIONS—
Spinning and forming tolerances to .031"

On each 5-ft. wheel, Spincraft assumed 100% fabricating responsibility: deep draw, spin, punch, blank, stamp and form, pantograph (chamfer), surface finish, drill, rivet, carton and ship. Operator (above) is spinning the ⅛-in. thick sheet of tough 52S aluminum alloy. Cross-section of basic wheel (right) shows unusual contour requirements. Raised segments are ½-in. cold rolled steel.



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World's largest plant fully equipped for all types of metal spinning • deep drawing • stamping • fabricating

Precision wheels with a "feel" for bowling pins — another example of Spincraft's fabricating skill

By setting pins faster, American Machine and Foundry's automatic pin spotter gives more bowlers more opportunities for better scores! Spincraft is proud to have successfully fabricated a key component of the AMF pin spotter. It's the large-diameter pin elevator wheel — our solution to a difficult production problem for this well-known manufacturer.

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Engage the facilities of the world's largest metal spinning plant — the only such plant also equipped for deep drawing, stamping and complete fabrication. You'll get results and savings that far exceed your expectations!

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Model A 23 Calivolter

C

Calivolter now available for immediate delivery

CALIDYNE'S NEW CALIVOLTER*

WHAT THE CALIVOLTER IS

The Calivolter is a precise electrical instrument which provides an accurate voltage output over a wide frequency range. True r.m.s. voltages regardless of waveform, and accuracy of ±½% are outstanding features. The Calivolter fills a long recognized need for an extremely accurate but inexpensive voltage standard.

*Trademark

WHAT THE CALIVOLTER DOES

The Calivolter may be used to measure accurately the e.m.f. of voltage-producing vibration, pressure, and seismic pick-ups, as well as strain-measuring devices. It provides a means for accurately calibrating voltage detectors and voltage-sensitive devices such as Vacuum Tube Voltmeters, Oscilloscopes and Sensitive Relays. It may also be used for over-all calibrations of Recording Systems, and for measuring the frequency-response of Amplifiers, Recording Systems, Transformers, High Impedance Meters, etc.

WHAT THE CALIVOLTER OFFERS

Here are some of the advantages and features which you get with the Calivolter:

- *Accuracy ±½% from DC to 10KC — useful to at least 20KC.*
- *Voltage output from 10 microvolts to 10 volts in 5 continuous ranges.*
- *Easy operation, simple standardization.*
- *Low output impedance — max. 1000 ohms.*
- *No current waveform error.*
- *Current output — 1 microamp to 10 ma in decade steps.*
- *A transfer switch and input connection for "unknown" facilitates measurements by substitution.*
- *Small size (8" x 8½" x 4" o.a.)*
- *Lightweight (6¼ lbs.), sturdy construction, matchless quality.*

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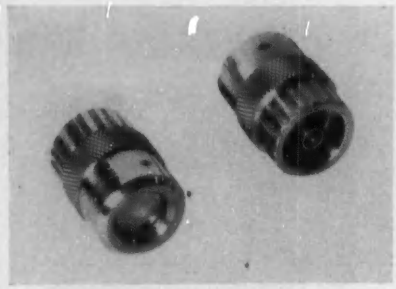
CANADA Measurement Engineering Ltd. Arnprior, Ont. Pierce 600 Toronto, Ont. Mayfair 5560

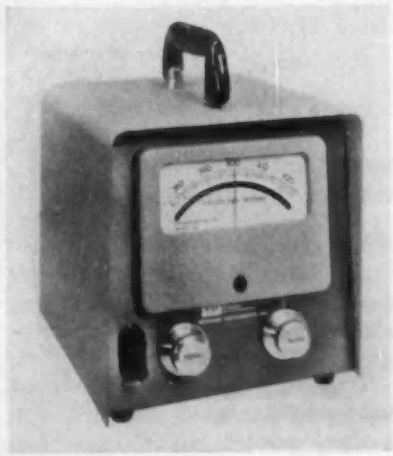
EXPORT Burke International Corp. 12 East 40th St., N. Y. 16, N. Y. Murray Hill 9-0200



the stainless steel housing to provide for special circumstances where circulating electrical currents may be present in the mounting fixture and for application of a calibrating voltage. It is provided with a double-shielded, low-noise cable into which a cathode follower may be inserted.

Open circuit sensitivity is 500 mv/psi; natural frequency 185 kc; pressure range 0.001 to 500 psi; frequency range 25 to 20,000 cps; temperature range −40 C to 90 C. Gulton Mfg. Corp., Metuchen, N. J.

For more information—
Circle 124, inside back cover



Expanded Scale Frequency Meters

This instrument was designed for making measurements of the frequency regulation of motor and engine-driven generating units. Input voltage harmonics of 5 per cent or changes in input voltage of ±10 per cent will not cause errors in frequency indication greater than ±½ cycle for the Model 401 or ¼ cycle for the Model 601. Shasta Division, Beckman Instruments, Incorporated, P. O. Box 296, Station A, Richmond, California.

For more information—
Circle 125, inside back cover

TIGHT and SECURE
LAP AFTER GRUELING LAP
in the Indianapolis "500 Mile Classic"

1st—BOB SWEIKERT
"I've got to be sure of tight connections. That's why I chose Everlock lock washers. They really stay tight."

Bob Sweikert

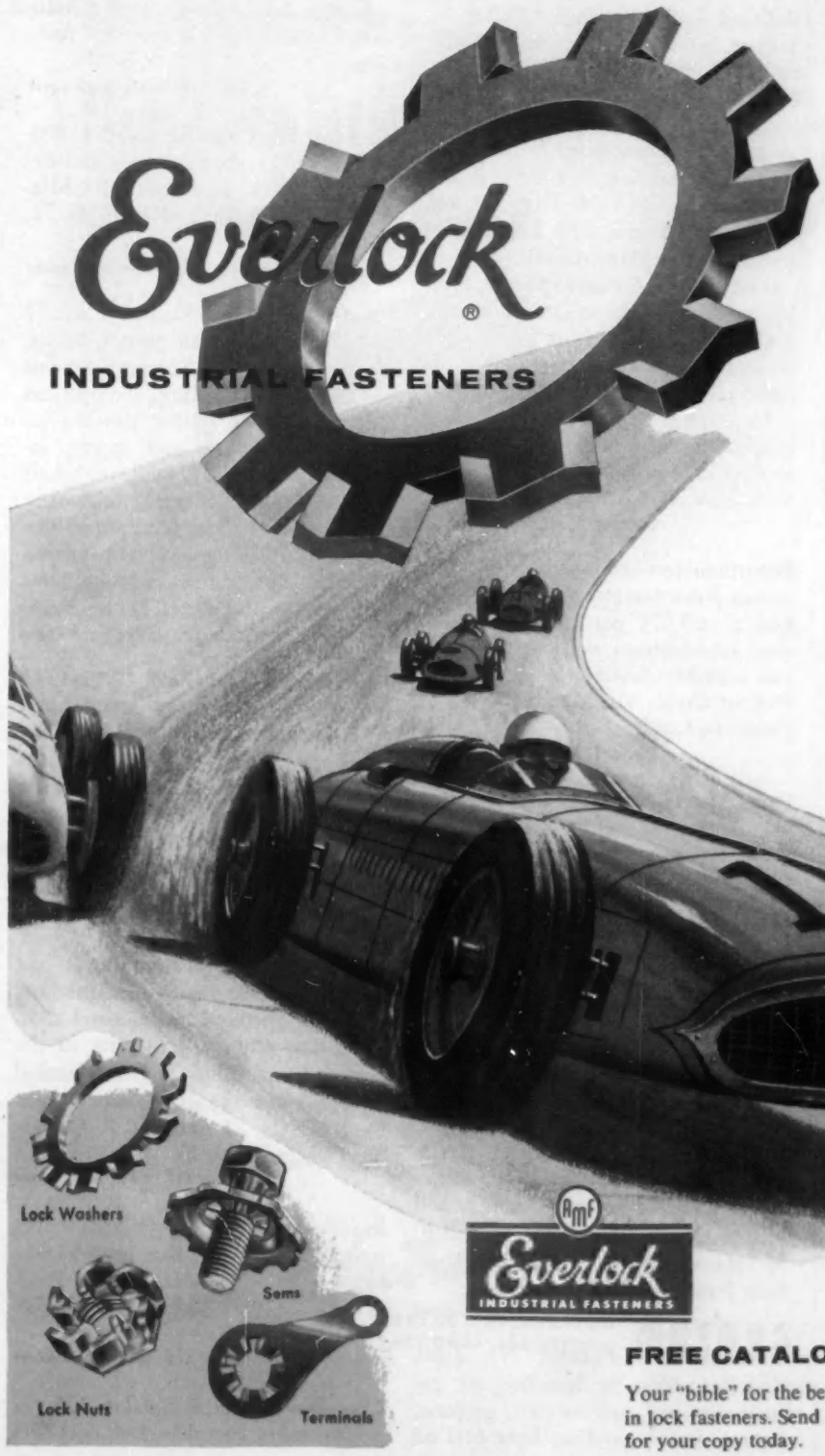
2nd—TONY BETTENHAUSEN
"Big or small, in every race my car is equipped with Everlock lock washers. I know I can depend on 'em."

Tony Bettenhausen

3rd—JIM DAVIES
"Everlock lock washers held perfectly tight all through the terrific punishment of the race."

Jim Davies

Everlock®
INDUSTRIAL FASTENERS



EVERLOCK lock washers keep vital connections tight under the unmerciful pounding of competitive racing. Their exclusive alternating chisel edges provide a *double surface grip* – actually bite into both screw and work with a *permanent*, vibration-proof grip.

To Keep Your Product Tight choose EVERLOCK and *fasten it* and *forget it*. In a complete range of stock sizes, types and materials, or to meet your individual "specs."

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Gibsiloy

REFRACTORY CONTACTS

maintain low temperature rise on new Westinghouse Quicklag-P Circuit Breaker

Gibsiloy W-10 is used as both moving and stationary contacts on this Westinghouse Quicklag-P Circuit Breaker.

On its new Quicklag-P plug-in circuit breaker, Westinghouse has installed Gibsiloy W-10 silver-tungsten contacts because they withstood a rigorous 5,000-amp short circuit test and maintained low temperature rise. These Refractory Gibsiloys carry the load, maintain low contact resistance, have high interrupting rating, and never need maintenance—factors which make them well suited for the Westinghouse Quicklag-P.

Gibsiloy W-10 is exceptional among refractory contact materials because of its high conductivity and high resistance to sticking when interrupting short-circuit currents. Because it maintains low temperature rise even with small contacts, it is especially appropriate for small circuit breakers similar to the Quicklag-P—using one pair of contacts per pole.

No silver plating of Gibsiloy W-10 is required to maintain low contact resistance during shelf life.

Temperature rise of circuit breakers and other electrical apparatus can often be reduced by adopting Gibsiloy W-10 contacts. To solve this and other problems involving contacts, call on the people whose business has been exclusively the design and manufacture of electrical contacts for 21 years. Let Gibson engineers know your needs.

Write for free Catalog C-520. It contains much useful technical information.

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Gibsiloy ELECTRICAL CONTACTS

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

Ball and Roller Bearings—Catalog 52, 140 pp, contains information on this manufacturer's line of bearings. General information about engineering and production methods are included along with more than 30 pages of general engineering data for ball and roller bearings. Charts, drawings and formulae are provided for bearing load computation. Dimensional and load capacity tables for each type of bearing are included, as are mounting details, shaft and housing fits and tolerances and drawings of typical applications.

Interchangeability charts, bearing weights and equivalent charts are in another section. McGill Mfg. Co., Valparaiso, Ind.

Circle 126, inside back cover

Potentiometer—Data sheet 54-11 describes potentiometer with linearity as fine as ±0.075 per cent. Construction, specifications, coil characteristics and available modifications are given. Helipot Corp., 916 Meridian Ave., S. Pasadena, Calif.

Circle 127, inside back cover

Panel Meters—Bulletin G-9, 7 pp, lists various types of meters and also shows some indicating pyrometers. Assembly Products, Inc., Chesterland, Ohio.

Circle 128, inside back cover

Vibration and Shock Mounts—Catalog AB-35, 8 pp, includes descriptions of standard and special mounting bases, and a selection of vibration and shock controls. T. R. Finn & Co., Inc., 200 Central Ave., Hawthorne, N. J.

Circle 129, inside back cover

Pneumatic Standards—Booklet, 12 pp, gives complete JIC pneumatic standards for sealing devices, cylinders and pistons. Miller Fluid Power Co., 2040 N. Hawthorne Ave., Melrose Park, New Jersey.

Circle 130, inside back cover

Solenoid Valve—Bulletin 743, 2 pp, describes valves for handling air, gas (manufactured and natural), propane, butane, water, gasoline, light fuel oil and other low viscosity fluids. Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle 131, inside back cover

Electrical Plugs and Receptacles—Bulletin B-59, 12 pp, illustrates and describes plugs and receptacles. Joy Mfg. Co., Oliver Building, Pittsburgh 22, Pennsylvania.

Circle 132, inside back cover

Powder Metallurgy—Manual E 55, 52 pp, is illustrated with photos, tables, charts and graphs. Separate sections are devoted to bearings, component parts and filters. Other subjects include design, loads and speeds, installation, press fit, close-in, shaft clearance, wall thickness, tolerances, temperature change, lubrication, machining, hardening, magnetic properties and flow rates. Amplex Div., Chrysler Corp., Detroit 31, Mich.

Circle 133, inside back cover

Wire and Cable—Booklet 19-5941, 11 pp, covers listings and specification data on power cable, control cable, appliance and fixture wires, apparatus leads, heating cable, defroster wire, aircraft wire, shipboard cable and generator leads. General Electric Co., Bridgeport 2, Conn.

Circle 134, inside back cover

Stainless Steel Wire—Manual, 32 pp, has tables giving size range and straightened lengths of the product, coil data, chemical analysis and characteristics, physical properties in the annealed condition and mechanical properties for cold drawn wire. Crucible Steel Co. of America, P. O. Box 88, Pittsburgh 30, Pa.

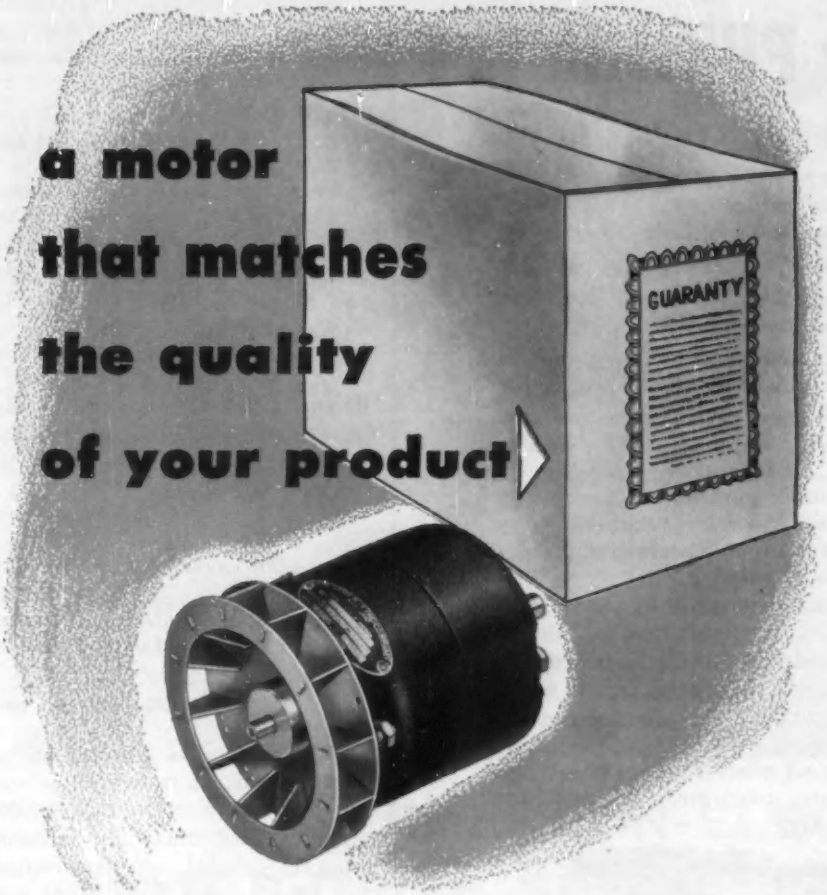
Circle 135, inside back cover

Switch—Bulletin, 2 pp, describes multi-button switch that provides two to 7 selective circuits. Soreng Products Corp., 9555 Soreng Ave., Schiller Park, Ill.

Circle 136, inside back cover

Compression Plugs—Catalog 300, 12 pp, furnishes complete technical data

a motor that matches the quality of your product



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Outstanding motor quality and uniformity are the result of our high degree of specialization in both equipment and methods, combined with rigid process control.

Your staff and ours working together can give *your* product the dependability and long life that result from this standard of motor quality.

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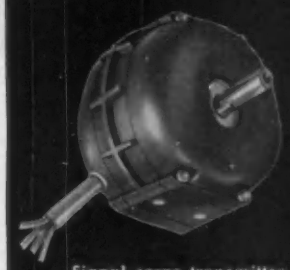
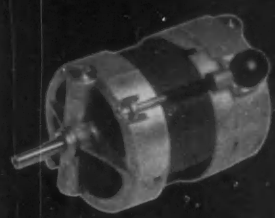
Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**



Signal corps transmitter blower motor.



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Turbine for canister- or cylinder-type vacuum cleaner.

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Catalogs and Bulletins.....continued

and drawings on polarized plugs. These include octals, loctals, miniatures and rectangular types of all-glass and all-metal construction. Hermetic Seal Products Co., 29-37 S. 6th St., Newark 7, N. J.

Circle 137, inside back cover

Electrical and Lubricating Devices—Catalog 55, 8 pp, contains descriptive data on all electrical and lubricating devices made by this company. Trico Fuse Mfg. Co., 2948 N. 5th St., Milwaukee 12, Wis.

Circle 138, inside back cover

Relays—Catalog, 18 pp, gives specifications and prices of relays available from stock. Relay Sales, 4721 W. Madison St., Chicago 44, Ill.

Circle 139, inside back cover

Timers and Counters—Catalog, 8 pp, describes electric stop clocks, high speed impulse counters and printing timers. C. H. Stoelting Co., 424 N. Homan Ave., Chicago 24, Ill.

Circle 140, inside back cover

Air Control Valves—Catalog, 66 pp, illustrates line of two-way, three-way and four-way valves for high or low-pressure installations. The following types are included: cam, flow control, foot, hand, interlocking, pilot, pressure regulator, quick exhaust, sequence, solenoid and time delay. Also presented are single and double-acting cylinders for air or hydraulic use and strainers for pipeline protection. Airmatic Valve, Inc., 7317 Associate Ave., Cleveland 9, Ohio.

Circle 141, inside back cover

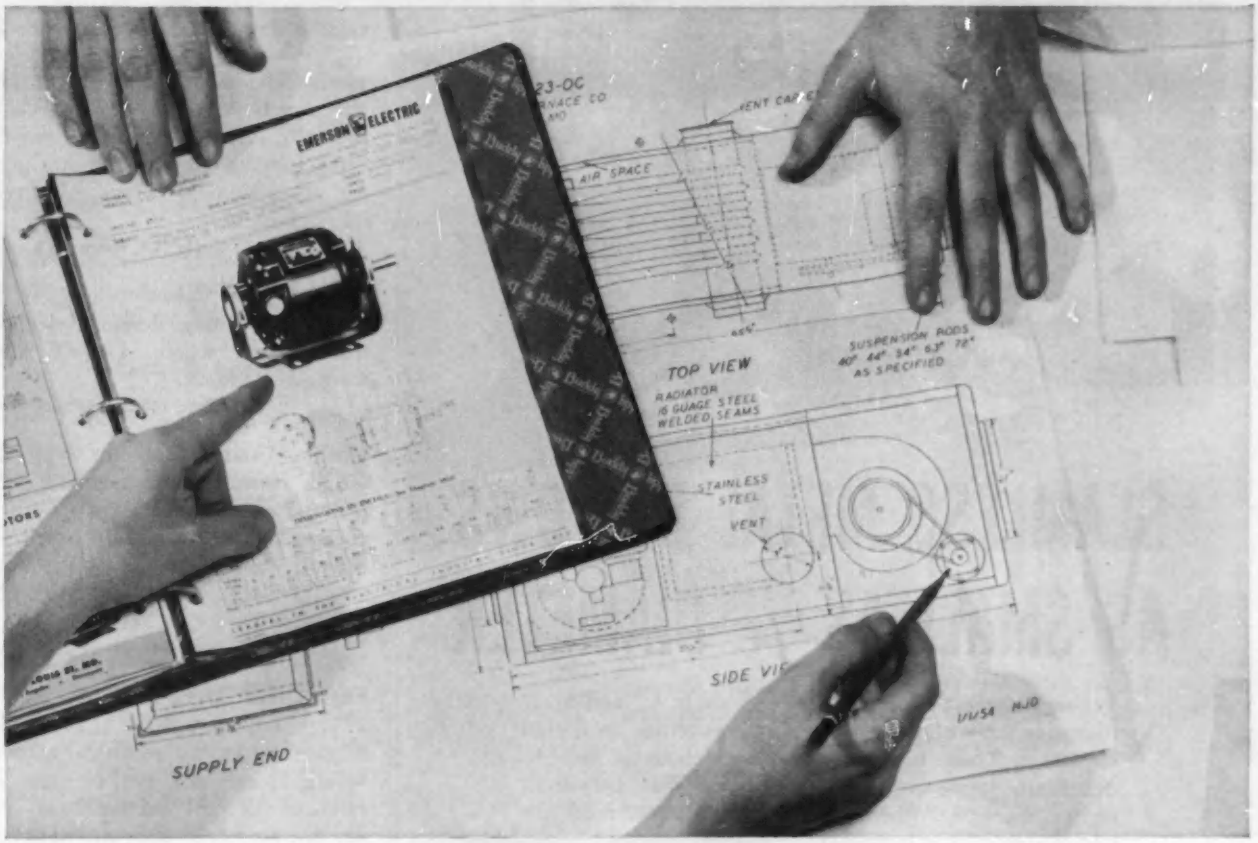
Milliohmeters and Microhmeters—Bulletin L-39, 2 pp, describes ten instruments for measuring low resistances between 0.0001 and 100 ohm. Shallcross Mfg. Co., Collingdale, Pa.

Circle 142, inside back cover

Investment Castings—Booklet, 16 pp, contains three tables listing composition and properties of carbon, low alloy, stainless, high temperature alloy and tool steel precision castings, and the magnetic properties of three of the most frequently supplied precision cast permanent magnets. Crucible Steel Co. of America, P. O. Box 88, Pittsburgh 30, Pa.

Circle 143, inside back cover

Plastic Steel—Folder, 4 pp, describes a product consisting of 80 per cent steel



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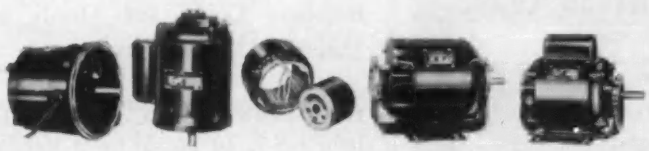

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powder and 20 per cent plastic resin that can be used to make models of products, certain types of jigs and fixtures, forming dies and molds. Chemical Development Corp., Danvers, Massachusetts.

Circle 144, inside back cover

Stainless Steel Valves—Catalog 55, 12 pp, covers valve design, selection, maintenance, repair. Cooper Alloy Corp., Hillside, N. J.

Circle 145, inside back cover

Cooling Control—Bulletin, 2 pp, describes control which regulates temperature of water in jackets or coils of equipment such as compressors, oil coolers, condensers and stills. Sarco Co., Inc., Dept. P. Empire State Building, New York 1, N. Y.

Circle 146, inside back cover

Deep Drawn Metal Boxes—Catalog 5, 21 pp, lists over 1000 sizes of aluminum boxes, all available without tooling charges and used by manufacturers of electrical, electronic and similar instruments as cases and housings. Zero Mfg. Co., P. O. Box 509E, Burbank, Calif.

Circle 147, inside back cover

Vibration Mountings—Bulletin K4A, 4 pp, gives engineering specifications and performance data for vibration, shock and noise control products. Korfund Co., Inc., 48-19C 32 Pl., Long Island City 1, N. Y.

Circle 148, inside back cover

Long-Stroke Diaphragm—Catalog B.F. 150, 16 pp, describes various classes of long-stroke, deep convolution diaphragms. Included are tables of standard sizes, available materials, dimensional data tables and design data. Illustrated with photographs and application drawings, it will be kept current by subsequent technical mailings. Bellofram Corp., 144 Moody St., Waltham 54, Mass.

Circle 149, inside back cover

Hermetically Sealed Connectors—Bulletin GS-5, 16 pp, includes standard AN types, K-general electronic series, miniature, sub-miniature, and rack-and-panel designs. Cannon Electric Co., 420 W. Ave. 33, Los Angeles, California.

Circle 150, inside back cover

Rod End Bearings—Catalog 2155, 4 pp, gives tables of dimensions and

load ratings. Southwest Products Co., Duarte, Calif.

Circle 151, inside back cover

Pipe Line Filters—Brochure, 4 pp, contains engineering, operating and application information. Also included is a table for computing of the correct size filter for a given installation. Air-Maze Corp., 25000 Miles Road, Cleveland 28, Ohio.

Circle 152, inside back cover

Pumps—Bulletin, 6 pp. Pump types described include those having a casing with removable suction cover and those having a casing with suction and discharge nozzles in one piece. Allis-Chalmers Mfg. Co., 1002 S. 70 St., Milwaukee, Wis.

Circle 153, inside back cover

Thrust Retainers—Bulletin, 4 pp, contains information on retainer selection, uses, application and advantages, installations and lubrication, as well as charts on dimensions and thrust capacities. Hartford Steel Ball Co., Hartford 6, Conn.

Circle 154, inside back cover

Relays and Actuators—Catalog, 49 pp, describes multi-contact relays, power relays, hermetically sealed relays and actuators. Phillips Control Corp., Joliet, Ill.

Circle 155, inside back cover

Electrical Heating Elements—Loose-leaf folder contains publications describing sheathed conductors and thermocouples and conductors for high-temperatures and sheathed heaters for liquid and gas containers. Ferrod Mfg. Co., Batavia, Ill.

Circle 156, inside back cover

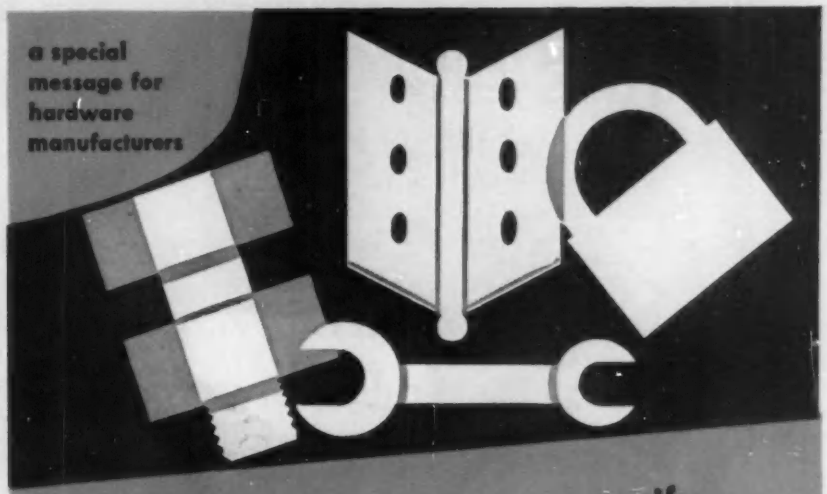
Rotary Pressure Joints — Bulletin S-2001, 8 pp, describes line of joints used to admit steam or other gases or fluids to industrial rolls and machinery. Johnson Corp., Three Rivers, Mich.

Circle 157, inside back cover

Expanded Aluminum—Folder, 4 pp, describes available sizes, dimensions and weights for different mesh sizes, and illustrations of a number of applications. Penn Metal Co., 203 E. 42 St., New York 17, N. Y.

Circle 158, inside back cover

Self-Aligning Swivel Joints—Catalog 265-B, 12 pp, contains specifications, dimensions and application data for



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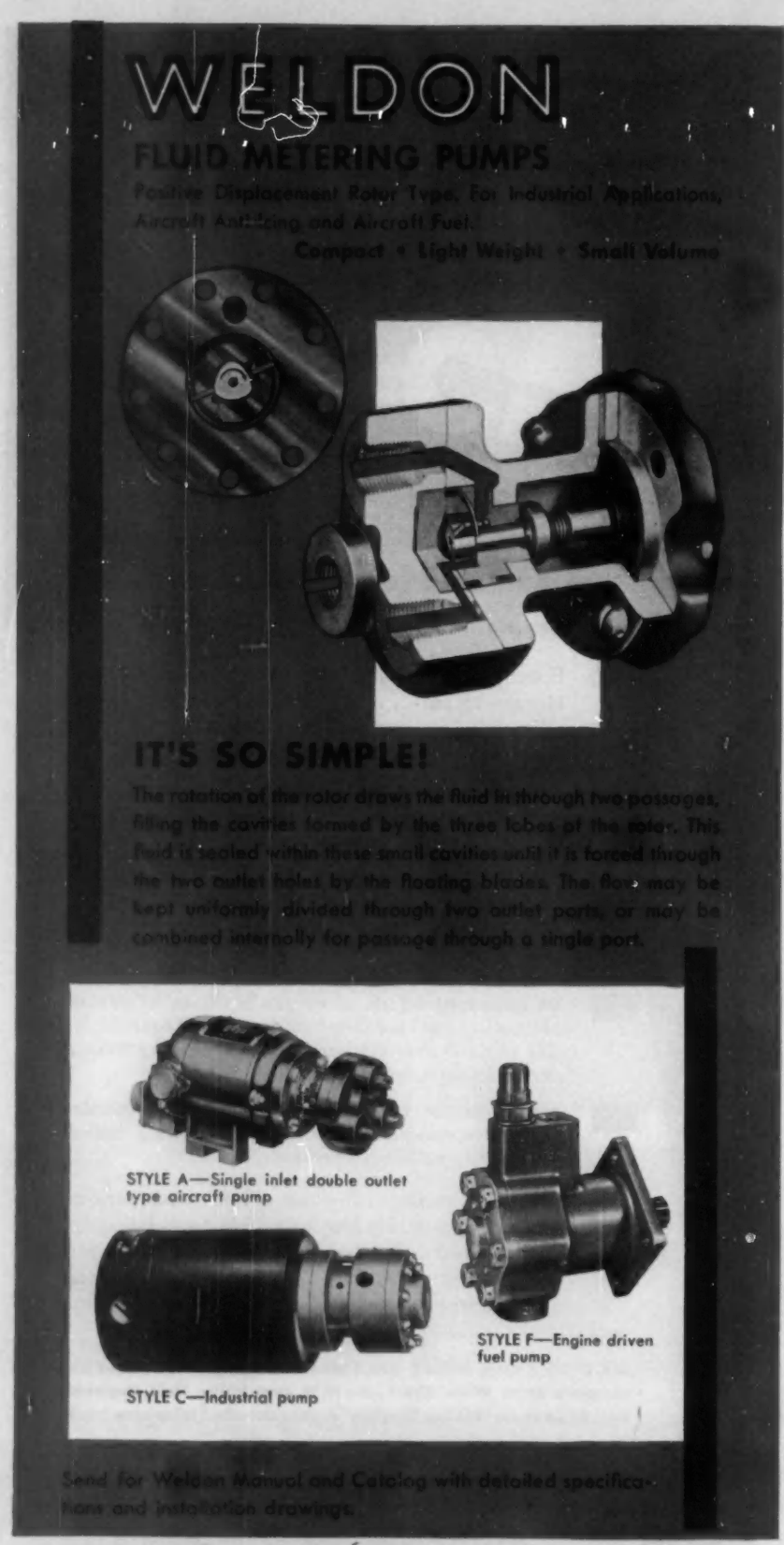
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this line of joints. Barco Mfg. Co., Dept. J-26, 501 Hough St., Barrington, Illinois.

Circle 159, inside back cover

Hydraulic Cylinder—Bulletin 1C-2.3, 8 pp, gives data on this cylinder, which operates on 500 psi, max, oil or 200 psi, max, air. National Pneumatic Co., Inc., 125 Armory St., Boston 19, Mass.

Circle 160, inside back cover

Environment-proof Switch—Bulletin P 103, 2 pp, describes roller-lever actuated limit switches, designed for use in both a-c and d-c applications. Micro Switch, Freeport, Ill.

Circle 161, inside back cover

Counter Switch—Bulletin 101, 2 pp, describes heavy duty, low force switch of the lever actuator type. Micro Switch, Freeport, Ill.

Circle 162, inside back cover

Expanded Stainless Steel—Folder, 4 pp, gives sizes, dimensions and weights of nine different meshes in various stainless alloys, both standard and flattened. A number of meshes, ranging from ½ to 1½ in. diamond size, are illustrated. Penn Metal Co., Inc., 205 E. 42 St., New York 17, N. Y.

Circle 163, inside back cover

Whiteprinter—Bulletin, 8 pp, describes machine that produces whiteprints at speeds up to 70 fpm. C. F. Pease Co., 2601 W. Irving Park Road, Chicago 18, Illinois.

Circle 164, inside back cover

Variable Differential Transformers—Bulletin LVDT-100A, 2 pp, includes dimensional drawings, test circuit diagram, a graph showing displacement of core from null point vs. output and frequency range, d-c resistance, impedance and weight. Gudeman Co., 340 W. Huron St., Chicago 10, Ill.

Circle 165, inside back cover

Strain Gages and Equipment—Price list, 12 pp, for SR-4 strain gages, instruments, accessories, and cements includes specifications for all sizes and types of bonded resistance wire strain gages, and tells how to select the right gage to meet various conditions of use. Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

Circle 166, inside back cover

Reciprocating Boosters—Pamphlet, 4 pp, illustrates and describes boosters,

rapid pressure build-up circuits, slow build-up circuits, mounting and dimensional data. Miller Fluid Power Co., 2040 N. Hawthorne Ave., Melrose Park, Ill.

Circle 167, inside back cover

Pneumatic-Hydraulic Systems—Bulletin 1C-2.2, 4 pp, contains details of actuating and control equipment. National Pneumatic Co., Inc., 125 Amory St., Boston 19, Mass.

Circle 168, inside back cover

Drum, Foot & Limit Switches—Catalog 5509, 48 pp, has engineering and application data, connection diagrams and dimensions. Furnas Electric Co., 1050 McKee St., Batavia, Ill.

Circle 169, inside back cover

Hydraulic Pumps—Bulletin DP-320, 2 pp, describes a dual vane pump designed for high speed direct engine drive, which can be operated continuously at 2000 psi and at maximum speeds from 2000 to 2600 rpm depending upon size. New York Air Brake Company, 1100 E. 22 Street, Cleveland 17, Ohio.

Circle 170, inside back cover

Induction Motor—Bulletin, 2 pp, covers a miniature, sub-fractional, 400-cps induction motor. Dalmotor Co., 1362 Clay St., Santa Clara, Calif.

Circle 171, inside back cover

Frequency Counter—Bulletin, 2 pp, describes applications, specifications and has block diagram of counter which measures 1 to 100,000 cps. Detectron Corp., 5528 Vineland Ave., N. Hollywood, Calif.

Circle 172, inside back cover

Magnetic Ingot Iron—Manual, 24 pp, describes a magnetic ingot iron for d-c applications, covering magnetic core uses, mechanical and physical properties, magnetic properties, permeability, annealing practice, machining, welding and drawing. Armco Steel Corp., Middletown, Ohio.

Circle 173, inside back cover

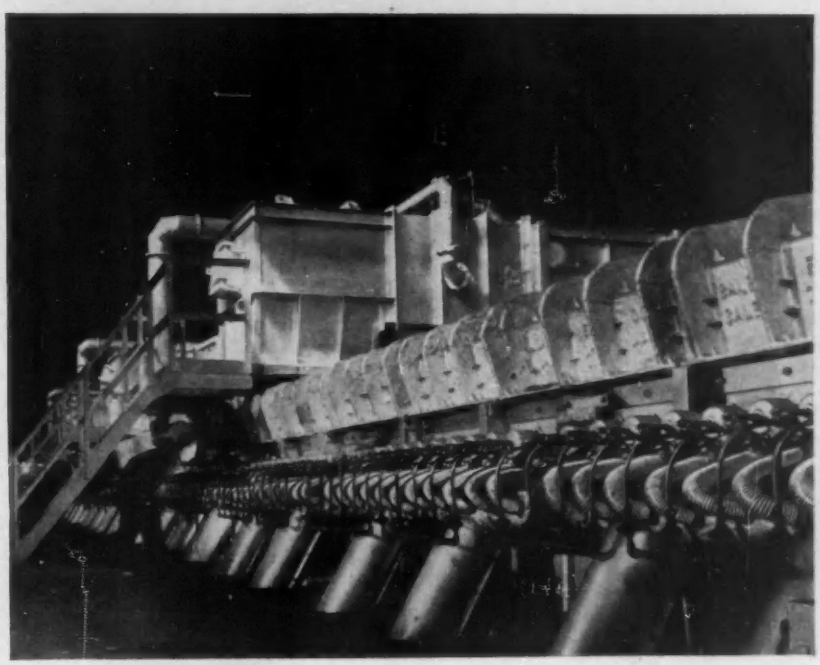
Adjustable Speed Drive—Bulletin PB4700-1, covers these packaged, prewired, pre-assembled units which provide the flexibility of d-c motor performance from an a-c power supply. Elliott Co., Jeannette, Pa.

Circe 174, inside back cover

Decimal Equivalent Chart and Calender dated July 1, 1955 to June 30,

FLEXON METAL HOSE *Design Briefs*

Vibration and Motion Problems in Gas Furnace Connections Solved with Flexon Metal Hose



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REX-TUBE interlocked, square locked and double groove type hose and tubing in steel, bronze, stainless steel and other alloys; sizes 3/16" through 12", I.D. for low and moderate pressures and for use as conduit, ducting, exhaust, protective armor, etc.

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Rex-Weld is ideal for services of this type because it is all-metal with no packing. It has the necessary flexibility combined with the ability to withstand high temperatures and high pressures. For all connections involving vibration, flexation, misalignment or expansion, specify Flexon Metal Hose. For specific recommendations send an outline of your requirements.

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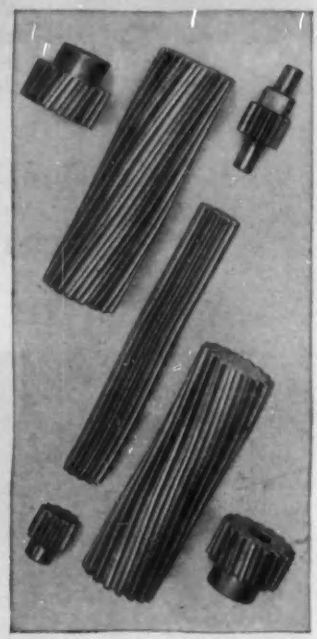

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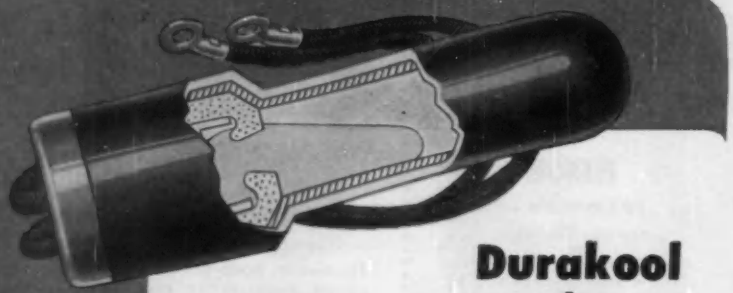

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Catalogs and Bulletins.....continued

1956 is available from Dayton Rogers Mfg. Co., Minneapolis 7, Minn.
Circle 175, inside back cover

Miniature Universal Joint – Catalog sheet, 2 pp, describes joint which provides uniform turning of a shaft without any speed fluctuations. Gear Grinding Machine Co., 3901 Christopher, Detroit 11, Mich.
Circle 176, inside back cover

Electronic Components – Catalog D-55, 12 pp, includes stand-off and feed-thru insulators, sockets and spaghetti. Also shown are various types of capacitors and resistors. Erie Resistor Corp., Dept. S, Erie, Pa.
Circle 177, inside back cover

Treated and Coated Fabric And Paper–Catalog, 20 pp, contains revised and added technical data, descriptions, photos, applications and information on treated and coated fabric and paper for electrical insulation users. Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Circle 178, inside back cover

Enameling Iron–Booklet, 32 pp, deals with the subject of porcelain enamel and enameling iron. A section on enameling iron covers such points as uniformity, surface, mechanical properties and gages and sizes. Other sections discuss design for porcelain enamel parts, fabrication, cleaning and pickling, good enameling practice, testing and safe crating. Armco Steel Corp., Middletown, Ohio.
Circle 179, inside back cover

Special Design Connectors–Bulletin, 2 pp. Illustrations show several unusual designs used in radar tracking equipment, high altitude applications, printed circuitry and computer equipment. DeJUR-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, New York.
Circle 180, inside back cover

Capacitors–Bulletin AB-21, 4 pp, describes molded plastic tubular metallized paper capacitor. Contains details, descriptions, performance characteristics and test specifications. Astron Corp., 255 Grant Ave., E. Newark, New Jersey.
Circle 181, inside back cover

Investment Castings–Wall chart is a comprehensive tabulation covering stainless, low alloy and tool steels,

nickel alloys, copper base alloys and aluminum alloys. For each alloy, the chart lists a complete chemical analysis and mechanical properties (heat-treated, annealed and as-cast). In addition, the chart rates the alloys as to castability, machinability, corrosion resistance, weldability, response to plating, response to heat treating and magnetic properties. Precision Metalsmiths, Inc., 1081 E. 200 St., Cleveland 17, Ohio.

Circle 182, inside back cover

Cold Finished Steel—Dictionary of terms, 32 pp, is for men who buy or use cold-finished steel bars. Included are more than 180 relatively detailed definitions frequently used in the purchase, manufacture, treating, machining and finishing of steel. La Salle Steel Co., Chicago 80, Ill.

Circle 183, inside back cover

Molding Materials—Wall chart compares properties of styrene molding compounds. Monsanto Chemical Co., Springfield 2, Mass.

Circle 184, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

Electrical Relays—Brochure, 70 pp, contains 23 technical papers covering all aspects of relays. Authored by leading relay specialists, the various papers were originally presented at the Third National Conference on Electromagnetic Relays held March 9-11, 1955, Oklahoma A & M College, Stillwater, Okla. Potter & Brumfield Mfg. Co., Inc., Princeton, Ind.

Screw Machine Products—Buyers' guide, 18 pp, covers such topics as what increases costs, design considerations, samples, drawings, grinding, burring, concentricity, plating and heat treating, finishing, inspection, overruns and underruns. National Screw Machine Products Assn., 2860 E. 130 St., Cleveland 20, Ohio.

Electronic Weatherstrip and Gaskets—Brochure, 16 pp, deals with the problems of suppressing rf leakage at its source. Its design section gives full design procedures, methods of installation, and lists standard stock items. Metal Textile Corp., Roselle, N. J.

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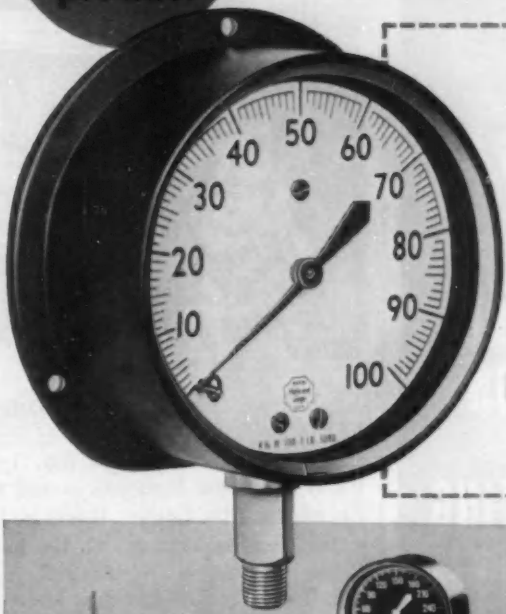
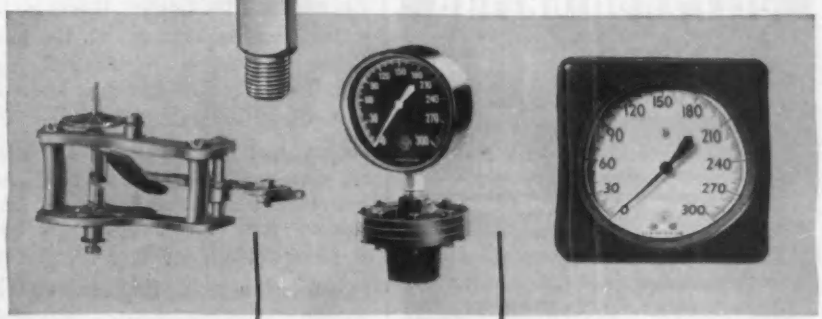


gages for pressure, vacuum or compound service



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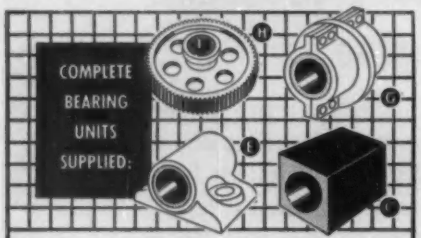

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Ad Libbing by the Editor

Before these words get into type I will be on the high seas bound for England and for Europe. It will be my second great experience "on the Continent," the first having been 42 years ago. That was only one year after the first diesel engine oil tanker, the Hagen, had been built. Most steamers were still being coal fired and two-stage steam turbines were considered "tops" for ocean going vessels.

Things which we take for granted today, such as radar, ship to shore telephonic communication, air-conditioned staterooms, and the broadcasting of meteorological information from shore to ship, while possibly dreamed of, were not yet developed.

Several things still stand out clearly as I look back upon that jaunt in the summer of 1913. One was a trip to the Hagenbeck Tiergarten in Hamburg, Germany. Hagenbeck spent much of his time roaming through Africa and capturing wild animals for his zoo, which was famous for its magnificent collection of rare species and specimens.

In order to simulate as well as possible the natural terrain and surrounding of the animals in the zoo, Hagenbeck built deep ditches around the "enclosure" instead of building high wire fences. A wire fence only about a foot high kept the public a safe distance from the ditches. It had a pleasing effect as one saw the animals roaming around apparently with nothing to keep them captive. The ditches could not be detected without looking carefully. It was a perfect illusion. Now some American "zoos" follow the same idea. Perhaps you have seen them in some of our larger cities and know how natural the settings are.

As I stood gazing at some of these animals a group of American tourists came up behind me, about a half dozen including two or three men. One of them suddenly shouted:

"Oh, I see what keeps the animals in. It's just a ditch. That's a hot one. Do these people think they can fool us that easily."

Such stupidity on the part of American tourists was quite common forty years ago, and according to reports still persists but to a much lesser degree. The American public is getting better educated in travel behavior but our tourists' behavior is still far below a standard acceptable to Europeans who must put up with them.

In most of the European countries the schools teach foreign languages. Many Europeans speak French, English and German fluently. For example, a Dutch student studies English for nine years and learns to speak it fluently. The students are taught by teachers who can speak the foreign language, and usually who have lived in the foreign country for an appreciable length of time.

In the U. S., foreign languages are supposedly taught in our public school system. Except in some instances the language is not taught, only the rules of grammar are taught. Usually, indeed almost invariably, the teacher cannot speak the foreign language she or he is teaching, not even haltingly. The teacher is unable to pronounce understandably the

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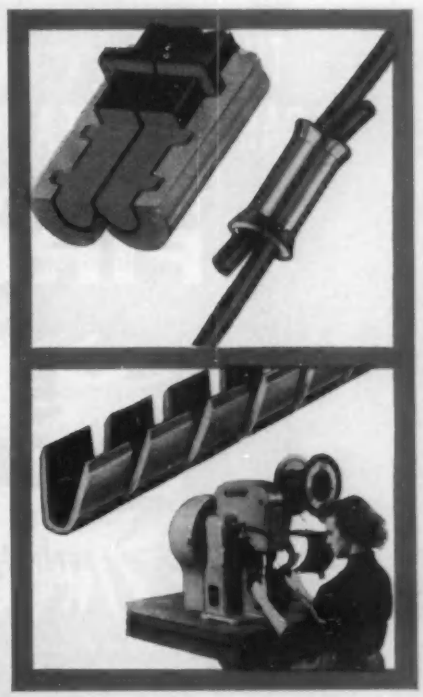

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most common words. The teaching of the rules of grammar is done in English, in so far as possible. Rarely do we find a native born American able to speak a foreign language that he has learned in public school.

In remarking upon this point, one of my friends said, "Why should an American learn a foreign language. Most foreigners speak English!" That remark is "one for the book."

By its language a nation expresses its feelings and emotions. Its language reveals many of the characteristics of its people. Many word sounds simulate the action they express. The English "whistle" puckers the lips and almost makes the sound of a whistle. But the German whistles in a different fashion and says "flöte'n" which also is close to the sound of his whistle.

Living in the land of sunshine the Frenchman speaks with soft lips and the sounds are made at the lips, for the most part. The Englishman speaks with his mouth, carefully pronounces every syllable and has beautiful diction that reflects his culture. The New York Americans don't use their lips, slur the syllables and often swallow their words, which is perhaps a reflection of their haste and unwillingness to exert themselves to speak clearly and distinctly. The gutteral Dutch is possibly a reflection of the growling anger of a staunch and brave people that have been conquered repeatedly and ruthlessly.

Now maybe all this can be argued, but one cannot argue the fact that we cannot know a people well if we do not know their language. When the American says, "Why should I know their language, they speak English?" it means that the American is perfectly happy to have the foreigner know him but he is too lazy to reciprocate or perhaps does not want to know the foreigner.

There is much talk about more courses in "humanities" for engineers. By all means let us have them, starting with modern languages taught by teachers who can speak the language fluently, and starting in the ninth grade of school.

It is high time that Americans ceased being so provincial. Or is that the wrong expression. Should it be "superior acting and ignorant."

My next Sans Souci will be written from Holland. —G.F.N.

ABSTRACTS

High-Temperature Durability Of Laminates

Abstracted from "High-Temperature Durability of Laminates," by George E. Power, Sr. Project Engr., The Formica Co., Cincinnati 32, Ohio, *Modern Plastics*, April 1955.

Laminated sheets were tested for flexural strength, loss of weight, and perpendicular dielectric strength at temperatures ranging from 125 to 250 C and were exposed for times up to 32 days. Materials included NEMA Grades XX (phenolic-paper), C (phenolic-canvas), N-1 (phenolic-nylon), G-5 (melamine-glass), G-7 (silicone-glass), AA (phenolic-asbestos), and G-1 (phenolic-glass), as well as experimental laminates made of glass fabric and heat-resistant phenolic, epoxy, diallyl phthalate and silicone resins. It is concluded that heat resistance can be defined only in terms of the behavior desired at the anticipated temperature. Characteristics of resins with respect to weight loss, softening, decomposition and crazing are given. These are presented in tabular form and in three-dimensional graphs that make it possible to visualize the entire time-temperature-property relationship. The high-temperature phenolics are seen to be promising and the epoxy and diallyl phthalate resins are shown to be highly craze resistant.

Design Considerations In the Use of Reinforced Plastics

Abstracted from "Design Considerations in the Use of Reinforced Plastics," by H. L. Darby, Vice Pres., Winner Mfg. Co., Inc.; presented at the 11th Annual National Technical Conference, Society of Plastics Engineers, Inc., Atlantic City, N. J., January 1955.

The manufacture of an item utilizing reinforced plastics involves not only the construction of a shape but at the same time the making of a material which can have a wide variance of properties with the following: type of resin and reinforcing material used, form of reinforcement, ratio of resin to reinforcement, ratio of other material and method of manufacture.

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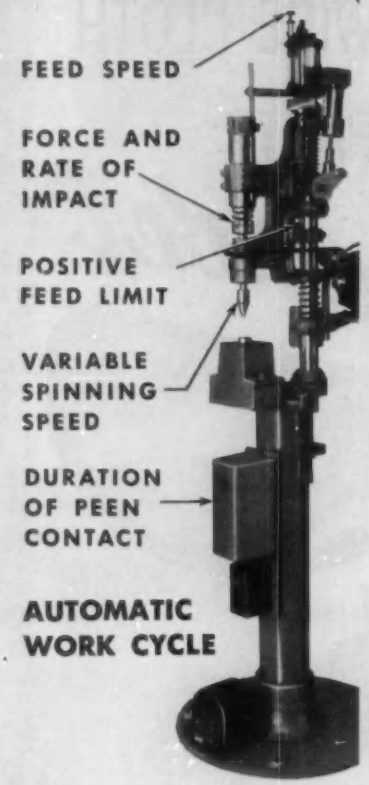

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the contact or no-pressure method, vacuum or pressure injection system, vacuum-blanket or vacuum-bag, positive pressure bag, and matched-die method. Molds used for reinforced plastics are made of plastics, aluminum, mild steel, cast iron, Meehanite and machine steel. Completely satisfactory sheet molds of plastic or aluminum have not yet been developed.

Reinforced plastics should be considered for corrosion resistance since they are unaffected by most corrosive agents. Good thermal, electrical and acoustical properties are found in these materials as well as a high strength-weight ratio. The lightweight inherent in reinforced plastic parts result in low handling and assembly costs. High impact strength is a design consideration which favors reinforced plastics. When a part is difficult or costly to produce in metal, it frequently can be made of reinforced plastics and serve its useful purpose.

How to Determine Manufacturing Method

To summarize the methods available and conditions contributing to the proper selection of a particular method, the following guide is offered:

A. Consider Contact or No-Pressure Method if you:
   1. Require low tooling costs.
   2. Require a prototype or only a few parts.
   3. Are not interested in maximum physical properties.
   4. Require only one good surface.

B. Consider Vacuum or Pressure Injection System if you:
   1. Can justify additional tooling costs to achieve two good surfaces and the part is simple in shape.
   2. Require a prototype or only a few parts.
   3. Do not require high physical properties.

C. Consider Vacuum-Blanket or Vacuum-Bag Method if you:
   1. Have small or limited volume requirements.
   2. Desire average, controlled physical properties.
   3. Are designing a part too large for existing mechanical equipment.
   4. Are forced to ask for undercuts or reverse draft angles.
   5. Have a large part with internal ribbing required.
   6. Require only one good surface.

D. Consider Positive Pressure-Bag Method if you:
   1. Have larger volume requirements.
   2. Desire good, controlled physical properties.
   3. Are designing a part too large for existing mechanical equipment.
   4. Require undercuts or reverse draft angles.
   5. Have a large part with internal ribbing and insert requirements.
   6. Require only one controlled surface.

E. Consider the Matched-Die Method if you:
   1. Have large volume requirements.
   2. Require good, controlled physical properties.
   3. Have no undercuts or reverse draft.
   4. Require two controlled surfaces.
   5. Require close tolerance control.
   6. Desire the lowest unit cost.

Fatigue Strength of Butt Welds in Structural Steels

Abstracted from "Fatigue Strength of Butt Welds in Structural Steels" by L. A. Harris, G. E. Nordmark and N. M. Newmark, Dept of Civil Engineering, University of Illinois, Urbana, Ill., *Welding Journal*, Feb. 1955.

In an attempt to improve the fatigue behavior of weldments a research program at the University of Illinois is being conducted under sponsorship of the U. S. Army Corp of Engineers. Work on the first phase of the research is reported, which was a study of the fatigue properties of butt welds under a wide range of conditions when using low hydrogen E7016 electrodes as compared to results with high-cellulose E6010 electrodes. Conclusions reached so far are as follows:

1. In general, the E7016 longitudinal butt welds, both with the reinforcement on and with the reinforcement removed by grinding, are slightly more resistant to repeated loadings than the E6010 welds, especially un-

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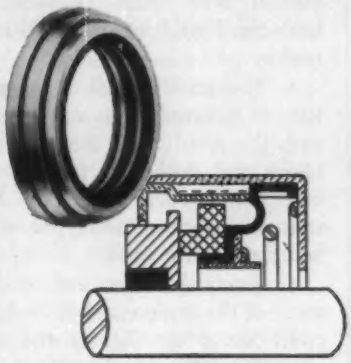

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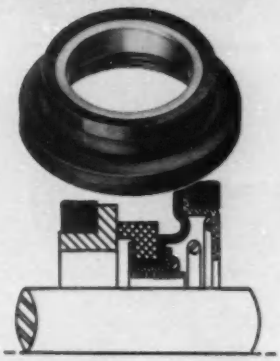

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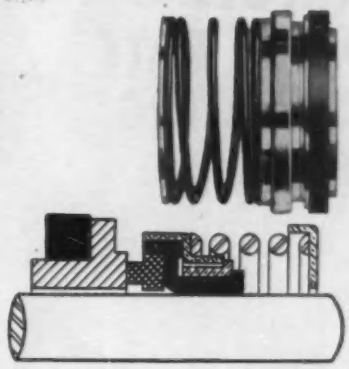

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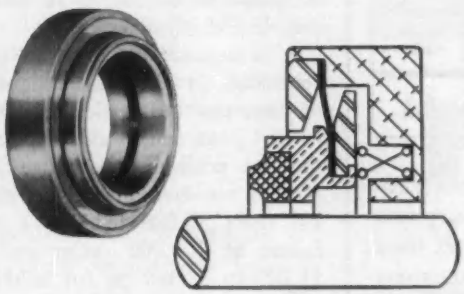

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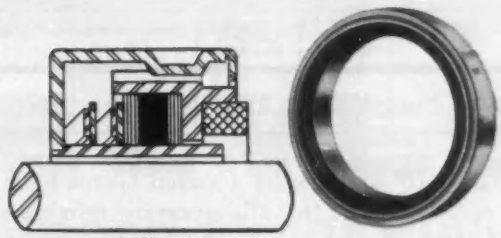

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der conditions in which failure occurs after a relatively low number of highly stressed cycles.

2. Removal of the weld reinforcement significantly increases the zero-tension fatigue strength of the longitudinal butt welds produced with both the *E*6010 and the *E*7016 electrodes.

3. The results of all of the present tests of transverse butt welds prepared with the *E*6010 and the *E*7016 electrodes fell within a narrow scatter band, differences in the fatigue strengths of the two types of weld being relatively small.

4. Removal of the weld reinforcement of the transverse butt welds generally decreased slightly the fatigue strength, with one exception; an increase was obtained in the fatigue strength of the *E*7016 welds for failures at 2 million cycles.

The following are conclusions based on the results of the re-evaluation of the past and the present fatigue tests of transverse butt welds in plain carbon *ASTM* A7 steels.

1. A large amount of scatter was encountered in the past fatigue tests of transverse butt welds. For the as-welded joints with welds deposited in the flat position, the range in the average zero-tension fatigue strength was from 30,800 to 37,900 psi for failure at 100,000 cycles and from 21,200 to 23,800 psi for failure at 2 million cycles. Individual butt-weld specimens might have a tension = compression fatigue strength as low as 9,000 psi for failure at 2 million cycles.

2. Generally, the tension = compression fatigue strength is 60 to 70 per cent of the zero-tension fatigue strength.

3. The welds deposited in the flat position have a significantly greater fatigue strength than those deposited in the horizontal or the vertical positions.

4. In general, there was no correlation between the fatigue strength and the location of failure, although the lower zero-tension fatigue strengths of the *E*6010 welds were usually associated with failure in the weld metal.

5. The welds prepared with the *E*7016 electrodes had slightly greater fatigue strength than those produced with the other electrodes.

6. Neither peening of each pass nor stress-relief heat treating of the com-

pleted weld consistently increases the fatigue strength of transverse butt welds.

7. Removal of the weld reinforcement generally, but not always, increases the fatigue strength of transverse butt welds.

Following are conclusions based on the results of the re-evaluation of the past transverse butt-weld fatigue tests in silicon steel and in low-alloy, high-tensile steel.

1. Butt welds in silicon steel have average fatigue strengths which are equal to or less than those of the butt welds in plain carbon steel, in spite of the greater yield and ultimate strengths of the silicon steel.

2. Butt welds in the particular low-alloy, high-tensile steels tested have fatigue strengths which are only as much as 20 per cent greater than those of butt welds in plain carbon steels, although the yield point of the low-alloy, high-tensile steel was about 65 percent greater.

3. A transverse butt weld joining a plain carbon steel to a low-alloy, high-tensile steel is likely to have a fatigue strength equal to that of a similarly prepared joint in plain carbon steel.

Weldability of Wrought High-Alloy Materials

Abstracted from "Weldability of Wrought High-Alloy Materials", by R. P. Culbertson, Head, Process Development, Haynes Stellite Co., Kokomo, Ind., *Welding Journal*, Mar., 1955.

Weld joints were made by the inert-gas-shielded arc and metallic-arc methods in high-alloy materials, including nickel-molybdenum, nickel-molybdenum-chromium, cobalt-chromium-tungsten-nickel, and N-155 iron-base alloy with large percentages of chromium, nickel and cobalt. The properties of the weld joints and the weld metal are satisfactory and fall within acceptable limits for alloys of this type. Weld joints in all of the alloys meet the minimum tensile requirements for the parent metal.

These alloys have characteristics of the austenitic type and, in general, can be welded by all of the methods common to the austenitic stainless steels. Certain of the alloys, however, exhibit characteristics peculiar to the particular alloy composition of the metal during welding and fabricating

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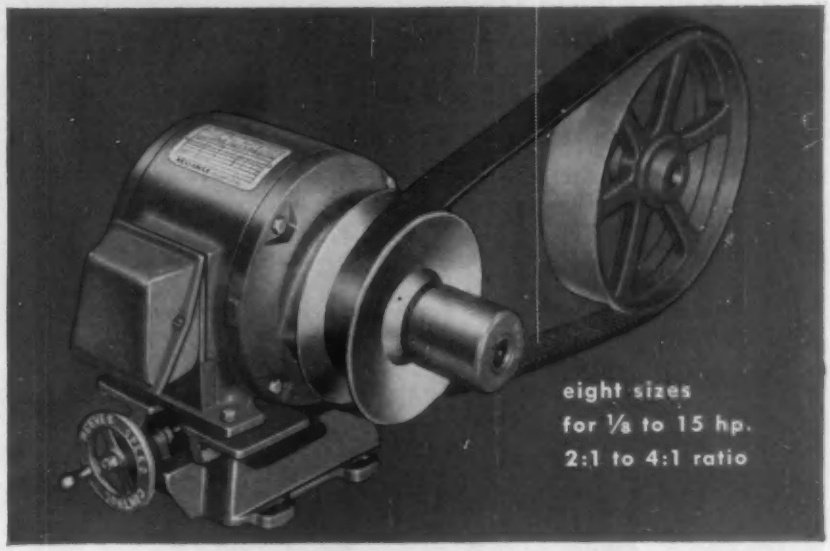

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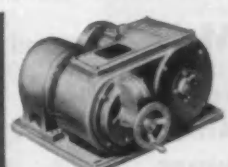

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operations. For example, nickel-molybdenum alloys are subject to stress-cracking in the hot-short range and are the most critical of the alloys in this respect. Nickel-molybdenum-chromium and cobalt-chromium-tungsten-nickel alloys are subject to work-hardening during forming operations. These alloys, however, are not as susceptible to stress cracking during welding of restrained components as are the nickel-molybdenum alloys. N-155 alloy is subject to micro-fissuring if proper welding techniques are not used.

All of the alloys can be welded satisfactorily when proper procedures are followed.

Eddy Current Press Drives

Abstracted from "Eddy Current Press Drives," by F. L. Hopf, Associate Member AIEE and T. R. La Vallee, Non-member AIEE, both of Eaton Mfg. Co., Kenosha, Wis.; presented at AIEE Winter General Meeting, Jan. 31—Feb. 4, 1955, New York, N. Y.

The requirement of more pieces per hour from all presses in a modern metal stamping plant has created many problems. Every press must operate at a greater number of strokes per minute with correspondingly higher punch velocity. This situation is aggravated by variations in steel sheets both from a chemical analysis and thickness consideration.

These problems instigated the development of better methods of driving and controlling presses. One system uses a direct-connected motor which starts and stops on each stroke. This drive is limited to the torque that the motor can develop, since a flywheel is not used. As a result, special high-torque motors are employed. This situation resulted in the application of an eddy-current clutch and brake as a press drive. The use of this combination which incorporates a flywheel permits selection and control of punch velocity anywhere in the stroke with a normal size standard induction motor. Models are available for single, double and triple-action presses rated 300 to 1500 ton.

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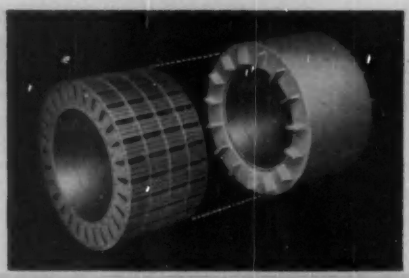

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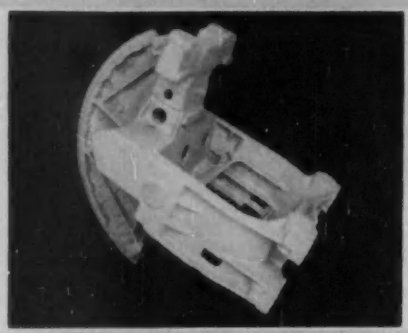
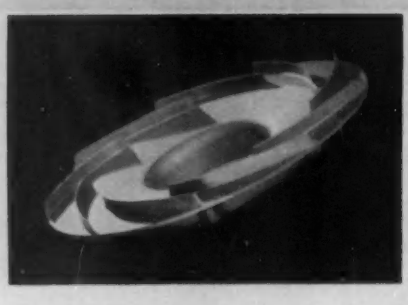


NIGHTMARE SPECIFICATIONS MET BY ROLLE MFG. CO.

Complicated internal structure, unequal wall sections, complex wall joinings, intricate internal webbing, make feeding and chilling stressed areas a nightmare in this sand casting. But Rolle Manufacturing is turning out castings able to pass 100% X-ray examination to highest aircraft standards in production quantities.



CASTING COSTS CUT 44.5% BY ROLLE MFG. CO.

Rolle recommended change from sand casting to permanent mold casting of this part, with guaranteed surface in required areas, between fins, of from 100 to 125 microinches. Change resulted in casting costs down 44.5%, and machining time cut in half.

ROLLE CAN SOLVE YOUR CASTING PROBLEMS

Your casting problems—sand or permanent mold, aluminum or magnesium alloys—can always be solved quickly and economically if you bring them to Rolle. But the advantages of fighting weight with strength with Rolle don't stop there. Some of the most impressive savings Rolle has made for customers involved castings that were never considered "problems."

You can get some idea, just from the few cases illustrated here, of how the use of advanced techniques . . . a change in casting method . . . variation in any of a hundred casting considerations, can bring immediate returns in either reduced costs or improved performance, or both.

Write now for a free booklet that tells how you can solve casting problems with Rolle.

FIGHT WEIGHT WITH STRENGTH with **ROLLE MANUFACTURING COMPANY**

311 Cannon Avenue Lansdale, Penna.

While it is possible through the use of direct-connected motors to achieve slow draw and speed variations within the drawing portion of the stroke, such operation is limited to available motor torque and is accomplished at relatively high cost. Similar operation can be obtained from a hydraulic press, but the initial cost is higher and the production rates are less.

Eddy-current press drives are available in sizes from 7000 lb-ft at 550 rpm to 120,000 lb-ft at 425 rpm. Similar brakes using the same coils and field sections are available to match the clutch capacities. It is possible through the medium of toggle motion to arrange a mechanical press for slow down and fast recovery. Any such fixed system has the inherent disadvantage of requiring almost a complete rebuilding job to alter the degree and rate of slow down. With an eddy-current press drive, the draw speed can be changed in a very short period of time to match the metal being processed or the job being placed in the press. For job shop operation the latter feature is particularly important as conditions vary over a wide range.

The use of the eddy current press drive requires no increase in motor sizes. The negligible slip occurring from capacity use of the press does not reduce the production rates.

Properties And Uses Of Reinforced Plastics and Other Related Materials

Abstracted from "Properties And Uses Of Reinforced Plastics And Other Related Materials," by E. F. Culwick, Manager, Molding Div., Winner Mfg. Co., Inc., presented at Eleventh Annual National Technical Conference of SPE, Atlantic City, N. J., Jan. 1955.

The first high-production item of polyester-glass fiber was the airborne radome. Since a laminate absorbs less than 1 per cent water, electrical and physical properties are acceptable for many applications. The dielectric efficiency of polyester-glass fiber in radomes is due to the low dielectric constant and power factor at radar frequencies; their values are not appreciably affected by the absorption of water. The low-frequency electrical properties, however, are poor after water immersion.

A recent development of a chem-

ical-resistant polyester resin has been evaluated when used in a mat laminate. It was found that a loss of strength leveling off at 40 per cent of initial values occurs when subjected to hot chemical solutions at 100 C for 3 months. The laminates resisted attack by most acid solutions at room temperature but deteriorated at elevated temperatures. Resistance to alkalies is questionable at room temperature for long periods (3 months or more) and notably poor at elevated temperatures.

In general the structural properties of polyester glass laminates vary directly with glass content up to 60 per cent glass by weight. Considering the multiplicity of reinforcement combinations available as well as the various molding techniques employed one can only generalize. Usually all-cloth laminates molded under the same conditions of unrestricted pressure, temperature, resin, catalyst and cure time will be of a higher glass content than mat laminates, depending on the weave. For example, a laminate made with a very coarse open weave would contain less glass than one of equal thickness made under the same conditions with a very fine, tightly woven fabric.

Combinations of fabrics and mats will result in a range of properties all of which will vary depending on the molding technique, be it hand lay-up cured at contact pressure; hand lay-up cured under vacuum, pressure bag or autoclave; matched die molded to a given pressure, or matched die molded to a given thickness.

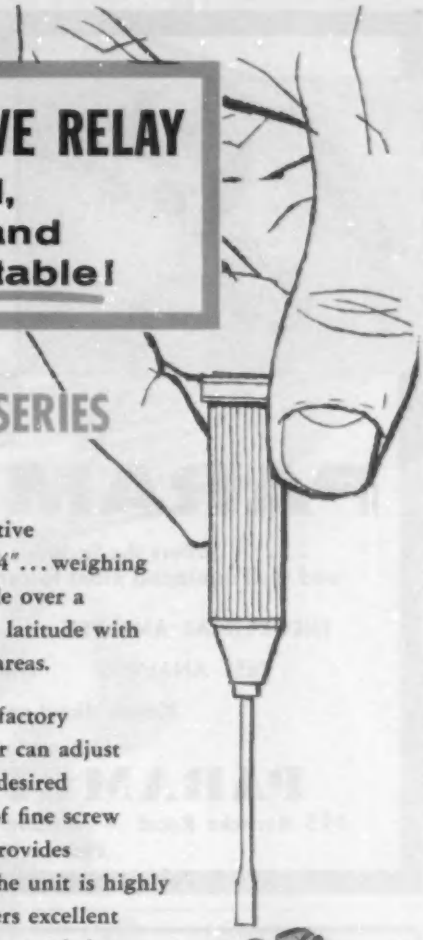
The most significant recent development in the field has been the new chemical finishes developed to improve the bond between the glass fibers and the resin.

Presently used glass fabric finish 114 shows a radical drop in strength of polyester laminates to high humidity, giving about 40 per cent drop in flexural strength on the average. Laminates made with fiber glass employing the new finishes retain between 90 and 100 per cent of their dry strength.

An evaluation of the electrical properties, dielectric constant and loss tangent at 10,000 megacycle of polyester glass fabric base laminates made with the new finishes show no appreciable difference from the 114 finish when tested dry. However, in the

UNIQUE SENSITIVE RELAY

incredibly small, lightweight and adjustable!



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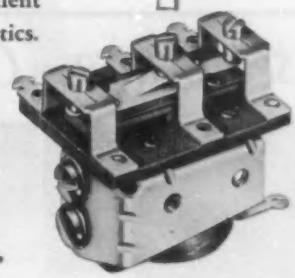
Here for the first time is a sensitive relay only 1-7/32"x 1-1/8"x 1-1/4"... weighing only 1-1/2 ounces, and adjustable over a wide range. You get much more latitude with this relay in designing for tiny areas.

The Advance "SO" is set at the factory to operate on 10 milliwatts. User can adjust it down to 2 milliwatts, or any desired pick-up or drop-out, by means of fine screw contacts. A balanced armature provides extremely sensitive operation. The unit is highly efficient, ruggedly built, and offers excellent shock and vibration-resistant characteristics.



Contact arrangement is SPDT. Coil resistances: 4000, 6500 and 10,000 ohms. Life expectancy: 250,000 operations. Available in open types... dust-tight or hermetically sealed enclosures. Now in quantity production, Advance "SO" relays are priced amazingly low. Write for literature.

Coil Resistance	Pick Up Voltage	Pick Up Current	Drop Out Voltage	Drop Out Current	Max. Coil Voltage for Continuous Duty	Overtravel	Contact Gap
4000	6.4 V	1.6 MA	3.2 V	.8 MA	110 V	.0015	.002/.003
6500	8.1 V	1.25 MA	3.9 V	.6 MA	140 V	.0015	.002/.003
10,000	10 V	1 MA	5 V	.5 MA	175 V	.0015	.002/.003

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ADVANCE RELAYS

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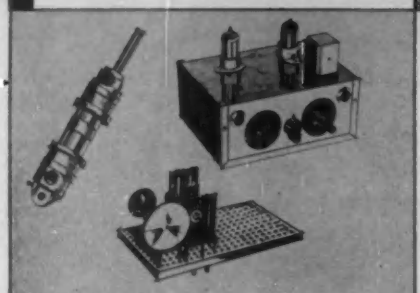
AN ELGIN NATIONAL WATCH COMPANY AFFILIATE



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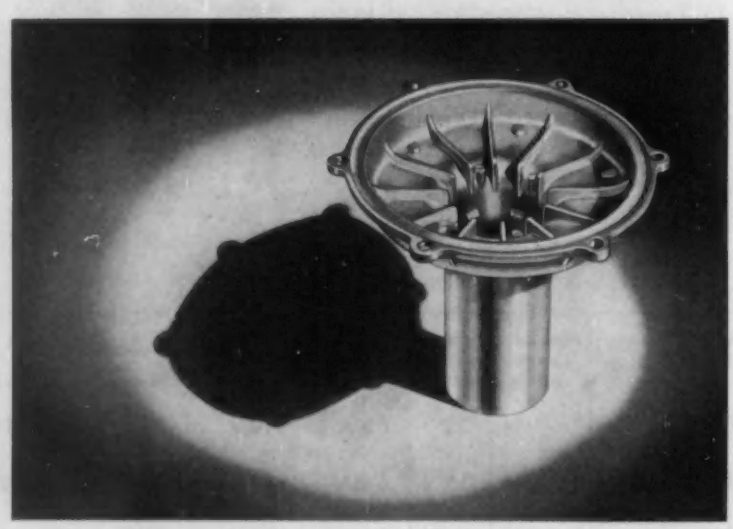

Die Castings reveal their superior quality

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PHONE ARmitage 6-4803

wet condition, after 24 hr. immersion in water at 73 F, both the dielectric constant and the loss tangent are slightly better.

In addition to polyester laminates employing glass fiber mat and/or cloth for reinforcement there are applications using molding compounds which are putty-like materials consisting of resin, filler, catalyst, chopped glass fiber and pigment.

Of necessity, these compounds, require the use of matched dies, preferably highly polished steel telescoping dies, for better filling of the mold cavity and easy part removal. Molding compounds are particularly suitable for molding parts of varying wall thicknesses and configurations which are usually difficult to obtain in matched die molding of pre-forms or mats and cloths.

Although large parts have been molded (6 sq ft of projected area) molding compounds seem best suited for smaller, more intricate parts, such as electrical insulators, housings, handles, base plates.

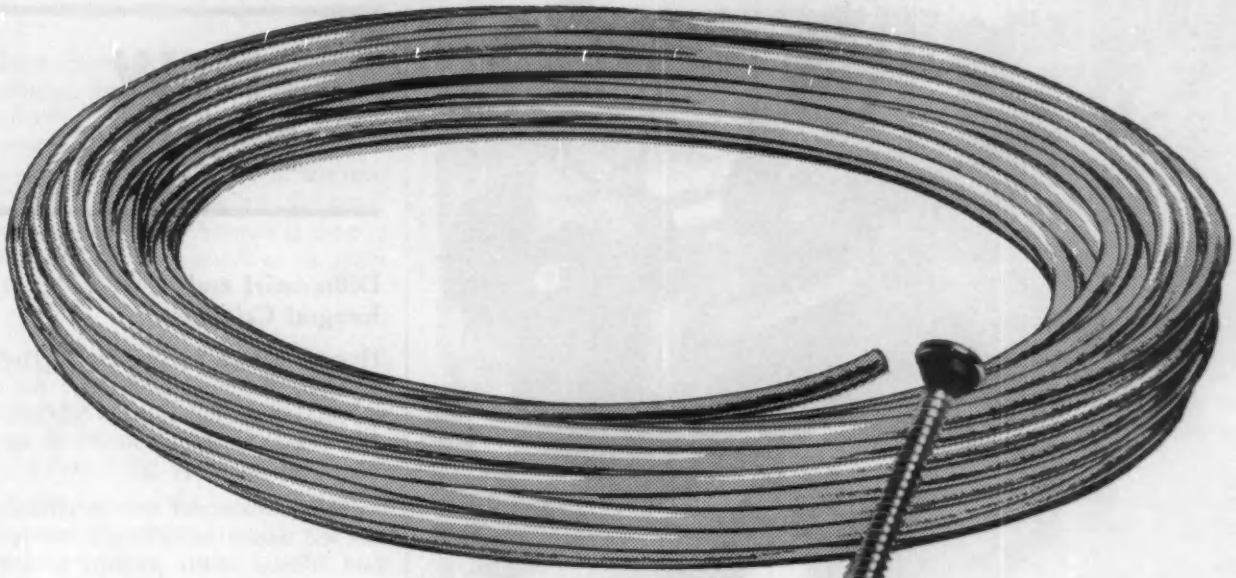
Epoxies are roughly three times the cost of polyesters and their use is therefore limited to special applications.

Lightweight reinforced fixtures employing glass cloth, epoxy resin and pipe braces are now used for drill racks, routing fixtures, trim fixtures, checking fixtures, welding fixtures, assembly fixtures and the like.

Very often the polyester glass fiber fabricator finds himself working with phenolic casting resins. Molds for prototypes, die models, spotting models, stretch blocks and jigs are often cast of phenolic resin in combination with suitable filler.

Unfortunately, cast phenolics have certain inherent properties that limit their usefulness. The catalyst used in curing the resin is generally acidic, so much so that if unprotected metals are left in contact with the casting, rapid corrosion ensures. This can be combatted to a certain extent by neutralizing the exterior casting surface. Eventually, however, the acid works its way out to the surface again. All contacting metal must be acid-resistant, lacquer-coated.

Cast phenolics must be designed to operate in compression since their tensile strengths are low (on the order of 6,000 psi). In many cases this limits their scope.



they grip tight...seal tight
—they're made of

CRUCIBLE
stainless steel cold heading wire

These *Tuff-Tite** fasteners, made by Townsend Company, New Brighton, Pa., have a neoprene washer preassembled into the head. They stop leaks... hold tight even where there's severe vibration... seal out moisture effectively.

Of course high speed production of these fasteners, like other types of screws, bolts, rivets and pins, demands cold heading wire with optimum workability. That means wire that's structurally sound and metallurgically uniform... with sufficient ductility to make forming easy... and with good tensile strength.

Crucible stainless steel cold heading wire has all these qualities — *plus* exceptional corrosion-resistance. That's why Crucible Types 305 and 410 stainless are used for the new *Tuff-Tite* fasteners, as well as for many other types of fasteners.

Crucible will fill your stainless cold heading wire needs quickly and efficiently... in the grade and size that best fits your application. Talk over your production requirements with your Crucible representative soon. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

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Write now for your free copy of Crucible's new 32-page booklet on Rezistal stainless steel wire.

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SKID-PROOFING

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NOISE-KILLING

SCRATCH-PREVENTION

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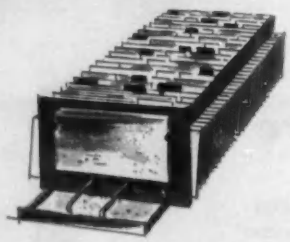
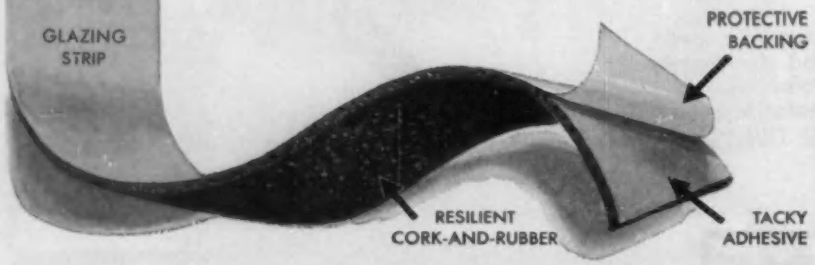
SKID-PROOFING



Give office equipment an economical, non-slip base with Armstrong DK-153 Tape. This cork-and-sponged-rubber material grips firmly, even on polished surfaces . . . makes equipment easier to use. And because it's resilient and non-marking, DK-153 also protects desk and table tops . . . eliminates the use of separate pads or cushions.

Armstrong DK-153 Tape is coated on one side with a pressure-sensitive adhesive that sticks to nearly any clean, dry surface. Just peel off the cloth backing and press tape into place.

DK-153 is available in tapes, sheets, rolls, or die-cut shapes and in a variety of thicknesses. For samples, write on your letterhead to Armstrong Cork Company, Industrial Division, 7307 Irvin St., Lancaster, Pennsylvania. Available for export.



Armstrong DK-153 TAPE

NEW BOOKS

Differential and Integral Calculus

HAROLD MAILE BACON, *Ph.D., Prof. of Math., Stanford University.* 6-½ x 9-¼ *in., 548 pp. Published by McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y.* $6.

This fundamental text on differential and integral calculus is a new second edition which presents a clear understanding of calculus as well as a practical working knowledge of the subject. It is intended primarily for the student, but is also useful to engineers desiring to refresh their basic knowledge of this subject. The material is presented as a highly readable and careful treatment of the theory of calculus and is illustrated by many examples and exercises in varying degrees of complexity.

The text is arranged in the traditional order. It begins with differentiation of all types of functions of a single independent variable. The definite integral is then introduced with numerous applications that can be handled by integration of functions of a single independent variable. Functions of more than one independent variable are then considered, first with partial differentiation, then with multiple integrals.

Additional topics of series and differential equations conclude the treatment. The order of presentation which is followed builds the reader's knowledge gradually, avoids confusion, and is designed to make the theory of calculus clear and with significance.

Because the concept of a limit is important the author has rewritten and clarified the introduction of limits. To conform to the modern practice of excluding reference to infinitesimals, the chapter on differentials has also been rewritten. Where necessary, the other sections have been brought up to date and made clearer. The book omits all materials, such as logarithmic and inverse trigonometric functions, which previously served only as a review and contained no calculus.

Although a number of sections have

been rewritten to provide a wide and concise exposition, the broad and effective use of calculus is demonstrated by many geometrical and physical applications included in the text. Of considerable value are the many exercises included. Answers to the odd numbers of these problems are given at the end of the book.

Designing for People

HENRY DREYFUSS. 5½ x 8½ *in.* 240 *pp. Published by Simon & Schuster, 630 Park Ave., New York, N. Y.* $5.

The story of the concurrent development of industrial design and the development of Henry Dreyfus as a designer. As the publisher says in the foreword, ". . . Dreyfus wanders over the world being empathic with service station men, ceramic designers, children, animals, proprietor of snack bars, ship's officers, owners of houses, renters of apartments." But this volume is not an autobiography in the usual sense; it almost approaches a handbook on industrial design, falling short only in omitting detailed data, specific case histories and design techniques.

One chapter, "Joe and Josephine," emphasizes that every thing the designer makes is used by people who come in many sizes, have numerous inhibitions and obsessions, are sensitive to noise, light and odors.

Some chapters do get more specific; for example, "How The Designer Works," "The Five-Point Formula," "Relationship of Designer to Client." A variety of specific design projects are brought in from time to time, but one of them—the telephone—is treated at full length in a chapter of its own. The design problem of creating comfortable living space inside a moving vehicle is also given a full chapter—covering mass transportation on land, sea and air.

But probably the most engaging chapter is titled, "Not By Design," where the author shows he is a human being as well as a genius—by telling stories on himself. In the closing chapter, Mr. Dreyfus offers his own appraisal of the future of product development in some rather specific comments.

The motivation for the book is rather clearly conveyed in this foreword; "We bear in mind that the object being worked on is going to be

the POWER and PERFORMANCE

OF YOUR PRODUCT

There's hardly a power driven machine built that doesn't depend on gears for its get-up-and-go—its productivity—and very often *its reputation.*

No wonder, then, why more and more manufacturers insist on Fairfield Gears for their QUALITY—and also for their mass-production ECONOMY.

No matter what type or size of gears you require, it will pay you to check with Fairfield first. Take advantage, too, of Fairfield's helpful engineering services. *Your inquiry will receive prompt attention.*

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SPUR GEARS—Straight, helical, and internal. Sizes from 16 pitch, 1½" dia., to 1½ pitch, 36" dia.
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HYPOID—Sizes from 1½" to 28" dia.
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WORMS AND WORM GEARS—Worms to 7" dia. Worm gears to 36" dia.
SPLINED SHAFTS—Lengths to 52". Diameters from 1" to 6".
DIFFERENTIALS—10,000 to 300,000 inch pounds capacity.

Note: All sizes above are approximate.

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ridden in, sat upon, look at, talked into, activated, operated, or in some other way used by people individually or en masse. When the point of contact between the product and the people becomes a point of friction, then the industrial designer has failed. On the other hand if people are made safer, more comfortable, more eager to purchase, more efficient—or just plain happier—by contact with the product, then the designer has succeeded."

Transistor Audio Amplifiers

RICHARD F. SHEA, *Head of Research Liaison, General Electric Co.* 6 x 9-¼ *in., 219 pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y.* $6.50.

Since its inception in 1948, the transistor has progressed to the stage of practical application. The primary purpose of this book is to provide the practical fundamentals of transistor application and to show how these fundamentals may be used in the construction of audio amplifiers. The author, an authority in this field, explains how the reader, employing a minimum of mathematics, may intelligently apply the principles set forth in the book to the design of these amplifiers.

The treatment in this book is general, and is applicable to the great majority of specifications which are currently available from the transistor manufacturers. Methods of transistor circuit representation are demonstrated which, in the author's opinion, are likely to be generally accepted. Conversion tables are included for the adaptation of these representations to others which may be encountered.

Much practical information is included of interest to the circuit designer. Data is presented on the variation of transistor parameters with the operating point, with temperature variations, and from unit to unit. Various methods of coupling transistor stages together are analyzed, and a number of examples of amplifiers designed for a variety of applications from preamplifiers to relatively high-powered output amplifiers are given.

This volume provides the technician and engineer with the method and data for designing audio amplifiers to meet desired frequency response, signal-to-noise ratio, input power and output power. These characteristics are obtained using the design information in the manner to insure maximum reproducibility, longest life, maximum freedom from the effects of temperature and humidity, and finally, the lowest cost.

Preceding the main text, a comprehensive table of symbols used is presented in five pages. Following the text, a detailed bibliography of articles appearing from 1948 to 1954 is included. This will be very useful for further study of any principle set forth in this book.

The Testing and Inspection Of Engineering Materials

HARMER E. DAVIS, *Prof. of Civil Engineering*, GEORGE EARL TWOXWELL, *Prof. of Civil Engineering*, and CLEMENT T. WISKOCIL, *Late Prof. of Civil Engineering, University of California.* 6¾ x 9¾ *in., 431 pp. Published by the McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y.* $6.50.

This text, now in its second edition, concerns itself almost exclusively with test methods and "properly organized experimentation." Courses and text in the mechanics of materials generally emphasize the theory, leaving room for only a cursory look at the now extensive field of engineering tests. Here the authors' aim is "to provide a general treatment of the principles and problems of testing with specific reference to the mechanical properties of engineering materials and to establish the basis for the inspection of these materials."

The subject matter includes an introduction to the theory of materials testing and then presents a survey of the means of measuring load, length and deformation. Testing machines, strainometers, bonded wire resistance strain gages, and brittle coatings are all briefly discussed.

Static tension and expression tests, shear and bending tests, hardness, fatigue and creep are included as well as an interesting section on nondestructive tests using penetrants, radiography, magnetic analysis and electrical analysis.

A chapter on the analysis and presentation of data introduces some valuable statistical considerations in the interpretation of test results. Twenty-

Chrysler Industrial V-8 Engines

...your kind of power —from the block up

It's true . . . Chrysler Industrial V-8 Engines are your kind of power. From the block up they are designed, constructed and equipped for heavy-duty operation. *Materials and components are the best from the standpoints of design, durability,* workmanship and performance.

Here, for example, are some of the quality features and materials you find in Chrysler Industrial V-8 Engines:

CRANKSHAFT—heavy-duty, forged steel, flame or induction hardened. Chrysler-exclusive undercut fillets for added strength. Fillets are shot-peened to counteract surface stresses and fatigue failures.

CRANKSHAFT BEARINGS—heavy-duty, tri-metal with Chrysler-exclusive cast copper-lead intermediate layer with nickel alloy dam to prevent possible corrosion caused by acids in oil.

Combination of Hardened Crankshaft and Heavy-Duty Crankshaft Bearings — offer greater resistance to the abrasive effects of dirt.

VALVE SPRINGS—twin concentric stainless steel. Extra strong dual springs operate as a unit, but either will operate valve alone should necessity arise.

VALVE TAPPETS—hydraulic, adjusting automatically to compensate for expansion, contraction and valve wear. Undercut to prevent sticking due to varnish or sludge deposits.

ENGINE COOLING—maximum allowable cooling water temperature rise between inlet and outlet is approximately 15°. Hottest spot in engine is only 20° hotter than the coolest . . . thereby reducing cylinder block distortion.

TIMING CHAIN—heavy-duty, wider than average for longer life.

PISTONS—aluminum alloy with thermostruts to control piston expansion.

EXHAUST VALVE ROTATION—positive, automatically spreads wear around the entire valve and valve seats. Valves make from ten to fifteen complete revolutions per minute at oil field speeds.

EXHAUST VALVES—extra hard stellite valve heads and valve seat inserts. Stellite seat inserts retain hardness in the presence of gases as hot as 1500°F.

SPARK PLUGS—resistor-type for long life. Spark plugs and wiring are covered for absolute protection against dirt and moisture.

DISTRIBUTOR—dirt and moisture proof with sealed cap.

Chrysler Ind. 24A
331 cubic inches
displacement Engine

Built around the famed Chrysler Hemispherical-Design Combustion Chamber, Chrysler Industrial V-8 Engines are *oversquare*—their bore diameters exceed the length of their stroke. The resulting short-stroke allows pistons and all other moving parts to operate at unbelievably slow speeds. Short-stroke also reduces friction, thereby allowing more power from same amount of fuel. Finally, with Chrysler Industrial V-8 Power you get a high-speed, short-stroke engine that will do fully as much or more than the slow-speed, long-stroke engine you may be using now . . . and you get an engine that costs less to buy, install and to operate.

Remember too, Chrysler Industrial V-8 Engines, like all Chrysler Industrial Engines, can be factory-equipped for operation with gasoline, natural gas or LPG.

To bring detailed information on Chrysler Industrial Engines, or to call in a factory representative, write: ***Dept. 67, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

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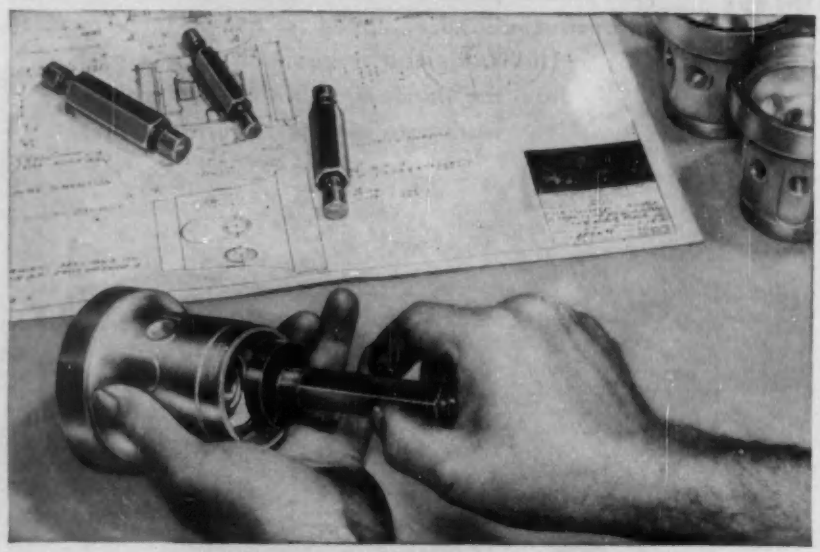
INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

WITH A PEDIGREE

Linde FLAME-PLATING NEWS

News of another successful use of LINDE'S process for applying a tungsten carbide coating to metal parts.



Flame-Plated plug, ring, and air gages have extra-high wear resistance for long-lasting accuracy.

Flame-Plated Plug Gages Outwear Carbide Gages 3-1... Hard Chrome Plated Gages 20-1!

Flame-Plating, a LINDE Service for depositing a thin coating of hard, wear-resistant tungsten carbide on metal parts and many tools, continues to be used with highly successful results on plug, ring, and air gages. The wear-resistant tungsten carbide coating, applied in LINDE's Flame-Plating plant, gives gages lasting accuracy through a longer wear life. Flame-Plated plug gages, for example, have actually outworn solid sintered tungsten carbide gages 3 to 1...hard chrome plated gages 20 to 1.

TEMPERATURE COMPENSATION PROBLEMS REDUCED

Flame-Plated gages have the same coefficient of thermal expansion as the gage base metal. When the gage base metal is similar or identical to the part being gaged, temperature compensation problems are either greatly reduced or eliminated entirely.

CHIPPING AND BREAKAGE PRACTICALLY ELIMINATED

Flame-Plating a gage with tungsten carbide produces a hard, wear-resistant surface while retaining the toughness of the base metal. Thus, the problem of breakage is greatly minimized especially on small diameter gages. The tungsten carbide coating is also highly resistant to chipping. These factors are important advantages over solid sintered carbide gages.

AVAILABLE NOW AT LEADING GAGE SUPPLIERS

Flame-Plated plug, ring, and air gages are now available in standard AGD sizes. Plug gages from .059-in. up. Ring gages from .375-in. up. Ask your gage supplier how you can cut inspection costs with Flame-Plated gages or call the LINDE office nearest you. Send for your free copy of the Flame-Plating booklet today.

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four carefully thought out problems at the back of the book may be a real boon to the harried instructor.

The spread of the subject matter is so wide that no one field is given the treatment it properly deserves. However, for the engineering student, it is just such a treatment that is required.

Supplemental Bibliography and Abstracts on Electrical Contacts

6 x 9 *in.*, heavy paper cover, 80 *pp. Published by ASTM*, 1916 *Race St., Philadelphia* 3, *Pa.* $1.

In 1952 the "Bigliography and Abstracts on Electrical Contacts" (ASTM STP No. 56-G) was republished. This new supplement includes all new references collected up to Jan. 1, 1954.

The subject index, although short, is comprehensive and self-explanatory. There is a subject index and also an index to authors. The references themselves are listed in numerical order with a separate section giving replacements and new references for the 1934 to 1950 period.

Appplied X-Rays

GEORGE L. CLARK, *Research Prof. of Analytical Chemistry, University of Illinois.* 6-½ x 9-½ *in.*, 843 *pp. Published by the McGraw-Hill Book Co., Inc.*, 330 W. 42 St., New York 36, N. Y. $12.50.

This is the fourth edition of a reference book that covers the entire field of X-ray science. These include history, instrumentation, engineering, physics, chemical effects, biology, medicine, crystallography structures and textures of materials.

The first half is concerned with generation of X-rays by means of the various tubes, the associated high voltage equipment, and instruments used in the measurement of intensity and quality. A discussion of X-ray spectra, radiography and microradiography should be of particular interest to engineers since it permits radiographs to be taken of objects in rapid motion in one millionth of a second. Radiographs are also widely used in the detection of defects in castings and rolled or drawn metal.

Hundreds of other applications of

radiography are mentioned including the examination of wood for flaws, porcelain insulators, glass and the counting of packaged materials such as cigarettes.

The second half of the book is devoted to the analysis of the ultimate structure of materials. The analysis of the crystal structure of pure metals and alloys, silicates, organic compounds, glasses, liquids and the texture of metals.

Not intended to give a detailed study of each of the many fields covered, the book attempts to provide enough material to deepen the interest of the reader to the point where he will take further steps himself toward the fundamental principles of interpretation of X-ray results.

New material includes the description of more recent equipment and microradiography. The interpretation of diffraction patterns and the discussion on textures of metals and polymers has been expanded.

Elements of Servomechanism Theory

GEORGE J. THALTER, *Director Engineering, Associate Professor of Electrical Engineering, U. S. Naval Postgraduate School* 6¼ x 9¼ *in., 282 pp. Published by the McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y.* $7.50.

This book is one of the McGraw-Hill Electrical and Electronic Engineering Series. The elements of feedback control theory and modern methods of application are presented on a level suitable for undergraduate study. The basic theory is presented without using operational calculus or complex-variable theory. The frequency-response methods of analysis are emphasized, since these are commonly used in practical engineering work. In order to provide adequate practice in modern techniques of system analysis both polar and logarithmic approaches are treated simultaneously.

This book covers loop systems and offers sufficient material on multiloop systems to introduce the problems involved and also the basic methods of solution. In order to integrate and compare the polar and logarithmic methods of solution, both are intro-

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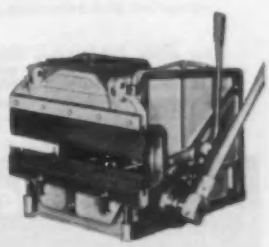

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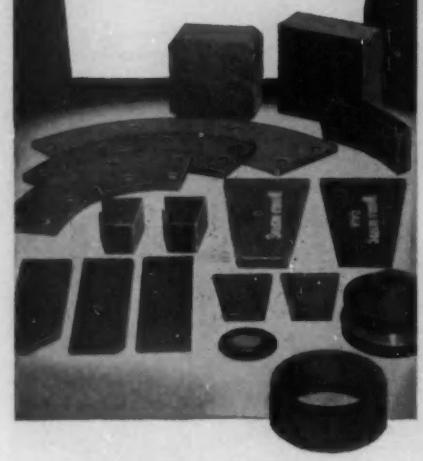

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High Speed Photography

6 x 9 in., paper-bound, 359 pp. *Published by the Journal of the Society of Motion Picture and Television Engineers, 40 W. 40 St., New York 18, N. Y.* $4.50.

This volume consists of all appropriate papers on the subject published in the Society's monthly journal, since the issuance of Volume 4 of this series. The papers are largely related to the First International Symposium on High-Speed Photography, held in Washington, D. C.

This is an excellent collection of papers dealing with both American and European techniques of high-speed photography. The book is divided into five distinct sections. The first deals with a description of various camera equipment; the second is concerned with the accessory equipment such as lighting and timing devices; and the third describes various applications in research and testing. The fourth covers a general survey of high-speed photography in Great Britain, in Europe and in the chemical industry. The final section is a series of papers devoted to statistical data pertaining to high-speed photography, such as the economics, the accuracy limitations of high-speed metric photography, and some material on the growth and decay of light from flash-discharge tubes.

This book is recommended reading for anyone who is faced with the problem of assembling or using high-speed photographic equipment for design, research and testing of various equipment such as machine tools, supersonic flow, explosive shock waves, combustion phenomena and electrical phenomena.

OUR READERS SAY . . . . . .

Letters should be addressed to The Editor, *Product Engineering*, 330 West 42nd St., New York 36, N. Y.

Advice For the Patent Office

To the Editor:

The perspectives appearing in *Product Engineering*, April 1955, regarding the dilemma of the backlog of applications in the United States Patent Office, was read with considerable interest.

A review of the data accompanying the budget requests of the Patent Office during the past few years provides a brief history of the determined efforts of the Office to reduce the backlog to a current status.

While the acceptance by the Patent Office of the recommendations of the Advisory Committee on the Application of Machines to Patent Office Operations will no doubt assist toward reduction of the backlog, still further relief may be realized by eliminating the need for the federal government to file patent applications on inventions in the fields where a monopoly is neither required nor wanted.

It is suggested that under revised statutes, a policy of publishing rather than patenting be adopted; thereby reducing the number of unnecessary applications field, and placing the Office in a position to serve better those who actually require the patent monopoly. —FRED H. BIERLEIN

Berkeley, Cal.

Proportioning Helical Springs

To the Editor:

My special interest in the question of proportioning helical springs for minimum weight has prompted me to investigate the accuracy of the method used by M .F. Spotts in his article published in November 1954, *Product Engineering*, page 193. In the fundamental formulas (1) and (2), the axial load P only is specified; meanwhile in the stress formula (1) P denotes a usually maximum work-

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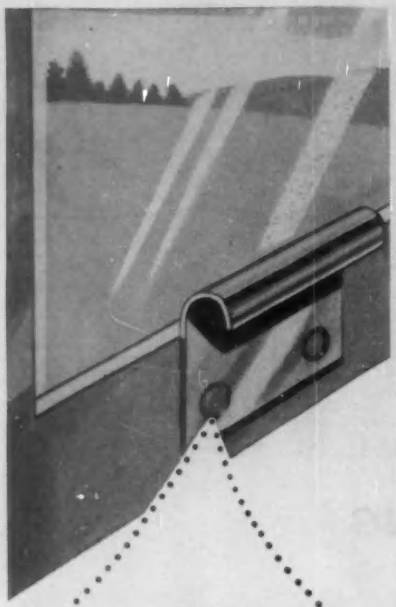

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ing load p_2, and in the deflection formula (2) P denotes difference between maximum load P_2 and initial preloading force P_1, or $P_2 - P_1$. Establishing the value of P_2 as a function of P_1 is not desirable. Further, Mr. Spotts introduces ratio $c = 2R/d = 8$ as a basis of securing the minimum weight of spring.

This assumption is doubtful due to neglecting the correction for stress concentration expressed by the well-known Wahl coefficient ϕ. The accurate stress formula should be written as follows: $d^3 = \frac{8P_2c\phi}{\pi S_v}$. Using data specified in Example 1 and selecting $\phi = 1.18$ we obtain: $d = 0.1134$ in., and

$$R = \frac{\pi \times 0.1134^3 \times 75000}{16 \times 40 \times 1.18} = 0.448 \text{ in.}$$

Number of active coils:

$$N = \frac{0.625 \times 0.1134 \times 11500000}{8(40 - 20)8^3} = 10.5$$

Weight of wire $= \gamma V$, where V is the volume of spring wire equal to $\frac{1}{4}\pi^2 \times d^2 NR = 0.299$ in.^{3} against 0.2044 in.^{3} mentioned in Example L. (Printed value of $V = 2.044$ in.^{3} is faulty). In order to make a proper comparison of data, based on standard sizes of spring wires, values of c, R, N and V are calculated from above formulas and collected in the table below. In addition, theoretical solid heights h are given, neglecting clearances between adjacent coils and number of end or inactive coils.

	1	2	3
d	0.1055	0.1205	0.1134
R	0.365	0.555	0.448
N	14.5	7	10.5
h	1.53	0.845	1.19
c	6.9	9.2	8.0
S_v	75000	74000	75000
ϕ	1.20	1.16	1.18
V	0.29	0.28	0.299
$2Rh$	1.12	0.94	1.07

From the table it may be seen that index $c = 9.2$ represents the best solution of the problem involved.

—Victor Tatarinov
Prague, Czechoslovakia

Ed:—Mr. Spott's answer to Mr. Tatarinov's observations appears below:

Use of the Wahl factor has the general effect of reducing the value of the stress when the spring is subjected to continuously varying load. Since

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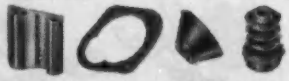

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the spring of Fig. 1 was not so loaded, stress concentration was neglected in the calculations of the example. Use of a lower stress will naturally give larger values for the required volume as indicated by Mr. Tatarinov's table. The writer believes the 2.044 figure to be correct.

Mr. Tatarinov is of course correct in pointing out that use of the Wahl factor gives a decrease in the amount of material as the value of the spring index c is increased. When equations (3), (4), and (5) are substituted in the equation for volume, the result is:

$$V = \frac{8P_1(\delta_2 - \delta_1)G}{(S_s)^2_{max}}$$

When the Wahl factor is employed, the value of $(S_s)_{max}$ increases as the value of the spring index c is increased. An increase in $(S_s)_{max}$ in the above equation causes a decrease in V, and this decrease continues so long as c is increased.

The principal contribution of the paper was to render some guidance when starting from scratch on the design of a helical spring. When arranged so that $P_2 = P_1$, a spring of mathematical minimum amount of material results. Equations (3), (4), and (5) of the article are so derived.

Reprints and Back Issues

To the Editor:

Enclosed is my $10.00 check for a 3-year subscription. Will this subscription include a copy of the 1955 *Product Engineering* Handbook? I certainly hope so because I'm quite anxious to acquire a copy.

Do you have back copies or reprints that can be purchased, or reference copies from which photostats or microfilm copies could be made?

—D. A. Tripp
Cincinnati

Ed–Supply of the 1955 Handbook has been completely exhausted, but you will receive the new Product Design Handbook Issue for 1956 this coming October as an extra 13th issue at no extra cost.

A limited number of tear-sheet copies of articles in current or recent issues can be supplied on request without charge. When the tear-sheet supply is exhausted we can supply

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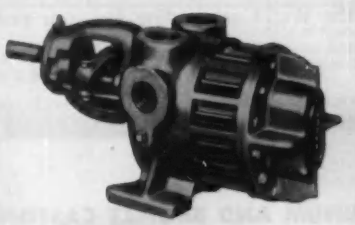

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To the Editor:

We are anxious to use the following two articles in connection with one of our classes: "Mechanics of Industrial Design," January 1953, and "Role of The Industrial Designer," September 1950. Are reprints available and what is the cost? Please reply by airmail as the material is wanted within the next few days.

—M. R. MARTIN, LIBRARIAN
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Ed—Reprints of the first article are available at 25¢ per copy. Copies of the second article will have to be photostated from our bound volumes at 40¢ per page.

To the Editor:

In *Product Engineering* for March 1936 there is an article on shear webs starting on page 93. Where can I obtain a copy of reference 6 at the end of this article? —W. E. ROBERTS
Toronto

Ed—The reference you request was a book "Structural Design of Metal Airplanes," published by McGraw-Hill Book Company in 1935. Unfortunately, this book as well as its second edition, "Mechanics of Aircraft Structures," are now both out of print. Perhaps your local library has copies.

To the Editor:

May we have copies of the editorial index for 1952, 1953 and 1954?

—Z. C. POSSIS

Ed—We are sending a copy of the 1954 index, but unfortunately, we no longer have copies of the 1952 and 1953 indexes. However, the complete index for the year is bound into the December issue each year.

To the Editor:

As subscribers to *Product Engineering* we would appreciate receiving eight copies of "Theory of Hydraulic Flow Control" by Nils M. Sverdrup in the April issue starting

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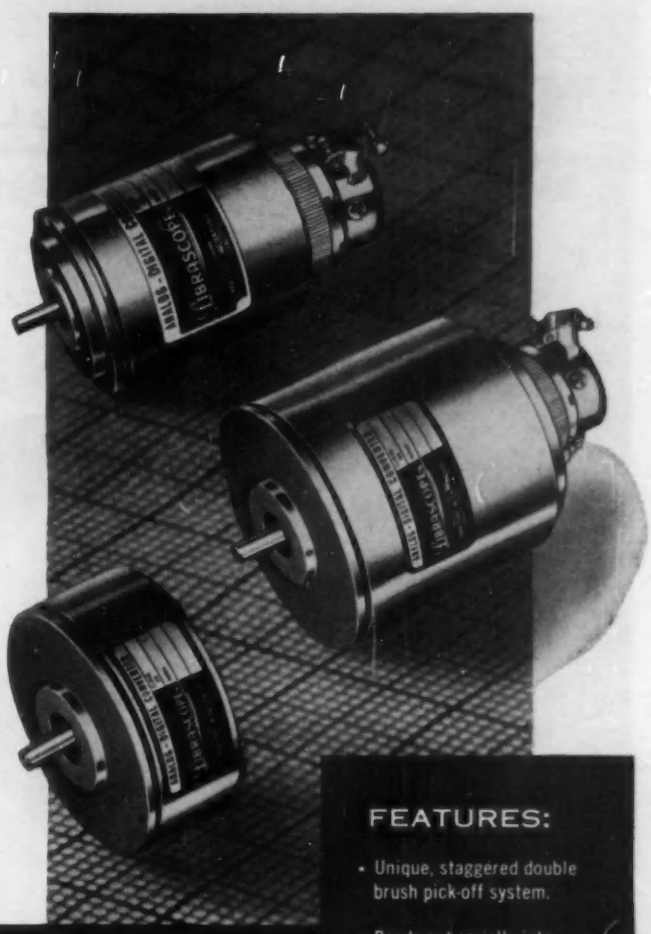

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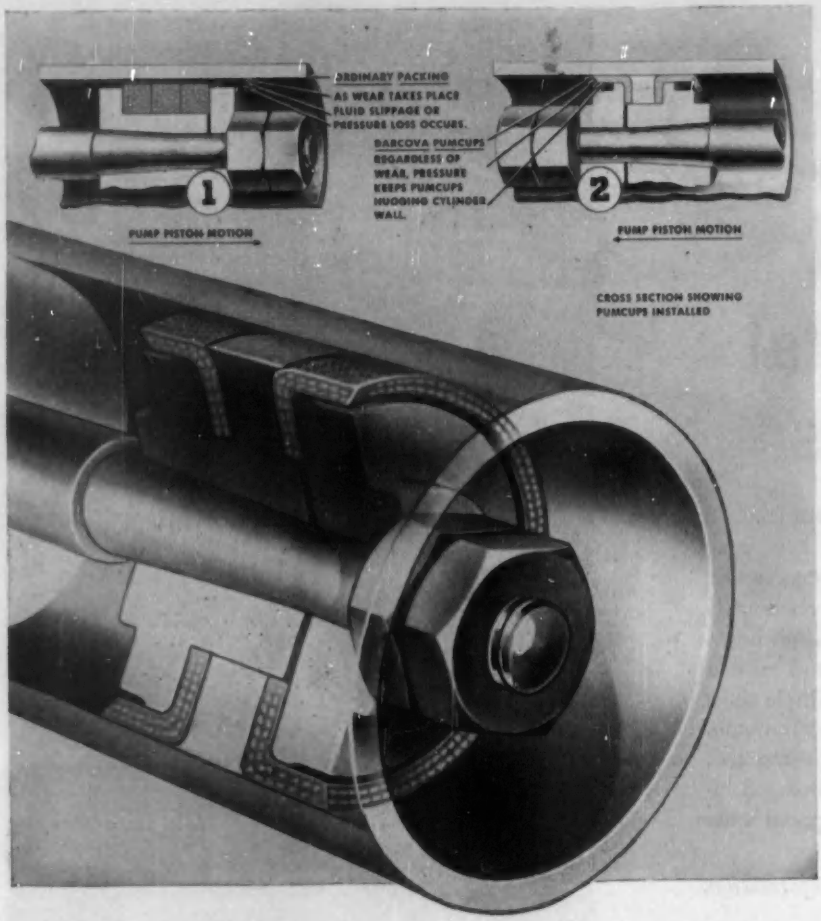

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on page 161, plus eight copies of each of the articles listed in the editor's note at the end of Mr. Sverdrup's article —M. PALMER
North Hollywood, Calif.

Ed—Because of the demand for copies of Mr. Sverdrup's article reprints have been prepared, and copies are available at 25¢ each. For the references you requested reproductions of the 9-page article in September 1953 can be supplied at 45¢ each (5¢ per page). For the two earlier articles in 1951 and 1952, we will have to supply photostats at 40¢ per page or a total of $4.00 for the two articles. The complete package is $4.70, and will be sent postpaid upon receipt of remittance.

A similar reply has gone to the many others who made the same request. Other readers wanting this complete file of reference data on hydraulic flow control can secure this "package" on requests accompanied by remittance of $4.70.

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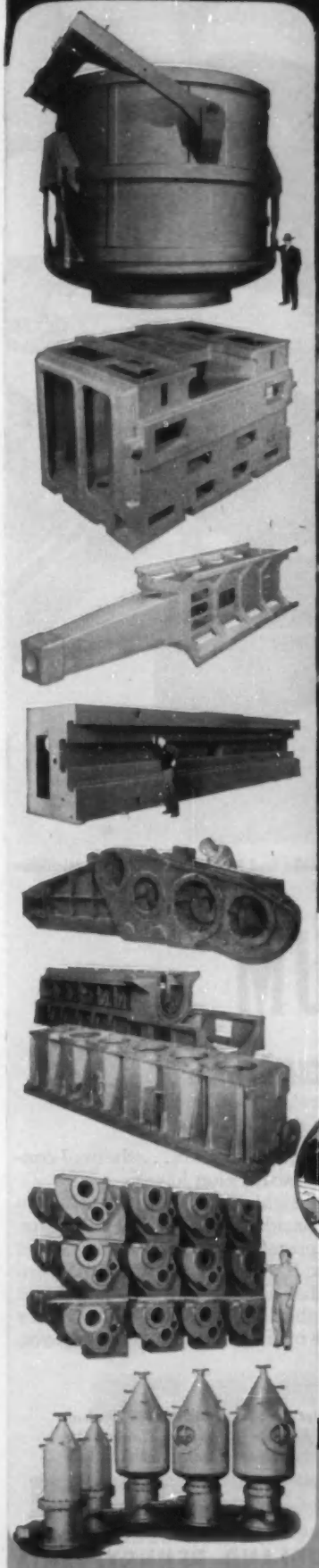
Insuring Your Progress Through Research, June 1953	50¢
Two-Wheel V-Belt Drive, Design Worksheet, June 1953	15¢
Rotating Components for Automatic Control, Nov. 1953	50¢
Fundamentals of Resistance Welding (Chart), Handbook	15¢
Electrical Symbols & Standards (Chart), Handbook	15¢
Non-Linear Techniques in Design, May 1954	25¢
Mechanical Components for Automatic Control, Sept. 1954	50¢
Science & Engineering, Jan. 1955	35¢
Theory of Hydraulic Flow Control, Apr. 1955	25¢

$5-Million Program For Basic Research

The Alfred P. Sloan Foundation, Inc., just announced the setting up of a specific fund of $5-million, both the principal and income of which are to be devoted to promoting basic research in the physical sciences. The decision for this fundamental research was made as of a result of a year's study made by five scientists headed by Dr. Roger Adams, research professor of chemistry at the Univ. of Illinois.

According to a spokesman of the Foundation, the study showed that, as a country, we are lagging behind in basic research, and that present efforts are insufficient. Also, it was conceded that in spite of the great scientific accomplishments in this country, far too great a proportion of basic research in the past has emanated from foreign sources. The U. S. has been an exploiter more than a discoverer.

Steel-Weld FABRICATION



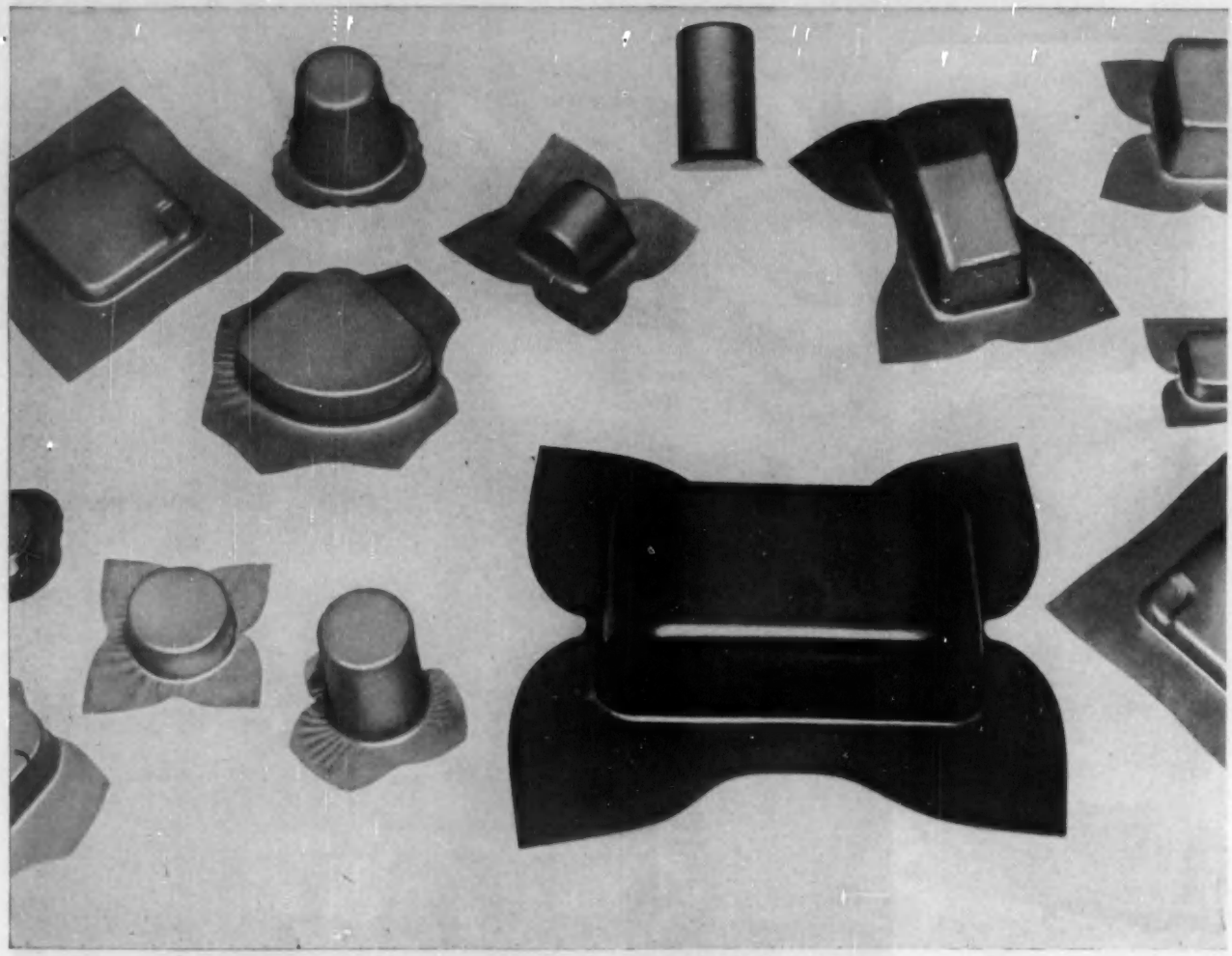
Use WELDED STEEL for Greater Strength with Less Weight!

Parts, assemblies and products, such as those illustrated at left, and the steam condenser unit being fabricated in the illustration above, are typical of thousands of Steel-Weld Fabricated units produced and machined by Mahon for hundreds of manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Mahon's service to buyers of welded structural or heavy plate fabrications is complete—including magnetic and radiographic inspection, machining, and assembling if desired. If you are a buyer of weldments, or welded steel in any form, you, too, will find in the Mahon organization a unique source . . . a source where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or write for Booklet showing Mahon facilities and capabilities in this field.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON



Deep-drawn parts made from REM-CRU titanium by Brooks and Perkins, Inc., Detroit, Michigan

now, make it TITANIUM even for deep-drawn parts

Titanium is a *practical* design material . . . even for deep-drawn parts. Techniques similar to those used for magnesium permit the forming of intricate sections without difficulty.

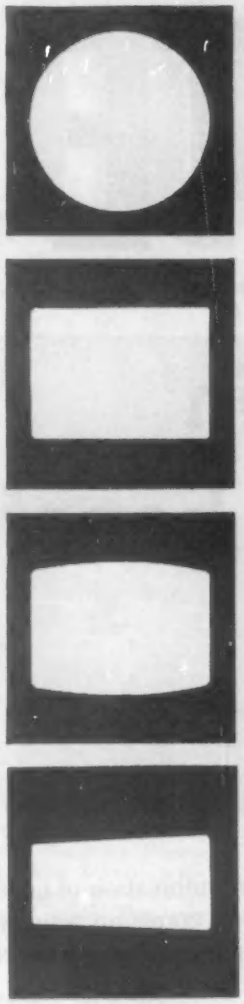
Deep-drawn and other fabricated parts of titanium have properties that make them truly remarkable. For instance, they're strong as stainless steel, but 44% lighter. They're exceptionally resistant to most forms of corrosion . . . entirely impervious, for example, to sea water or marine atmospheres. The modulus of elasticity is higher than for the other light metals . . . thermal conductivity and coefficient of expansion low.

So, for a tough, strong, light metal with many exceptional characteristics, consider REM-CRU titanium. And note that you'll get prompt delivery of the sizes and grades you order, because REM-CRU's substantially increased facilities mean that all standard mill forms and finishes are readily available. Let a REM-CRU engineer help you select the grade of titanium that will serve you best.

To keep abreast of the latest developments on this vital metal, write to Dept. P7 for the Rem-Cru Review—a free periodical presenting the latest technical data on titanium alloys.

REM-CRU TITANIUM

REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA



Ball Bearings

Cylindrical Roller Bearings

Spherical Roller Bearings

And now

Tyson **Tapered Roller Bearings***

The broadest product line in the anti-friction field.

SKF—and its field engineers—are now adding Tyson Tapered Roller Bearings to their recommendations.

Constantly working to broaden the SKF line—to make "the right bearing in the right place" a watchword throughout industry, SKF has recently introduced new lines of pillow blocks, styles and sizes of Max type ball bearings, the improved Type "C" Spherical roller bearing.

And *now* SKF offers Tyson Tapered Roller Bearings.

This means that from SKF you get the broadest range of types and sizes of anti-friction bearings *and* the most extensive anti-friction experience.

More today, than ever before, dealing with SKF Field Engineers assures you of the right bearing in the right place. TBA6

*Manufactured by TYSON BEARING CORP., affiliated with SKF Industries, Inc. as a subsidiary.

SKF®

BALL AND ROLLER BEARINGS

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.,
manufacturers of SKF *and* HESS-BRIGHT® *bearings.*

BAKELITE

BRAND

A major advance in fluorocarbons that benefits product design

6 WAYS...

Manufacturers of electrical and electronics equipment are discovering many benefits among the exceptional service properties of BAKELITE Brand Fluorothene. This rigid thermoplastic polymer offers such a combination of good dielectric properties, corrosion resistance, and physical toughness over a wide temperature range that it can function successfully where most other materials fail.

1 **BAKELITE Fluorothene's electrical properties** include outstanding volume resistivity that remains over 10^{14} ohm-cm. even at 390 deg. F. The material also has a low dielectric constant and high dielectric strength.

2 **BAKELITE Fluorothene shows no measurable moisture absorption** after long periods of submersion. This factor is instrumental in maintaining its high electrical values, even under extremely humid conditions.

3 **BAKELITE Fluorothene's working temperature range** extends over 710 deg. F.—from −320 to +390 degrees.

4 **BAKELITE Fluorothene has high compressive strength,** making it excellent for strong, tough parts. Hammer blows on a solid piece seldom scar the surface.

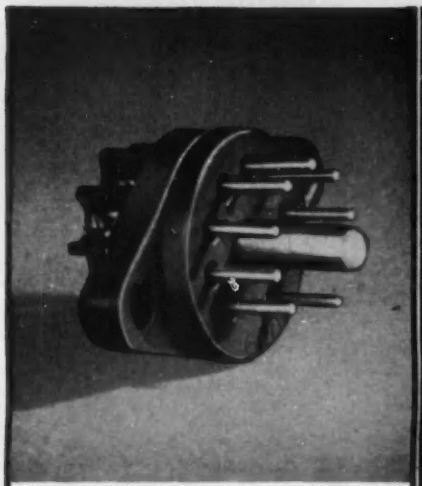
5 **BAKELITE Fluorothene has outstanding chemical resistance,** enabling it to function in extremely corrosive atmospheres. Furthermore, fuming nitric acid can be piped through fluorothene tubing.

6 **BAKELITE Fluorothene will not support combustion.**

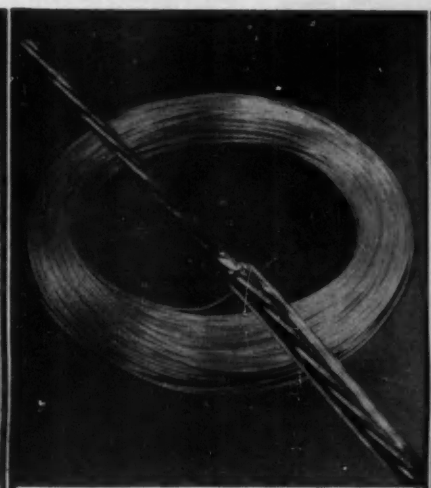
BAKELITE Fluorothene can be fabricated by compression or injection molding or by extrusion, with conventional plastics forming equipment. Typical products include tubing and rod stock, seals, gaskets, and insulation for printed circuits. Film and sheeting produced from BAKELITE Fluorothene is strong and tough and possesses excellent clarity. For information on the forms, properties, and applications of BAKELITE Fluorothene, write Dept. HC-145.

FLUOROTHENE

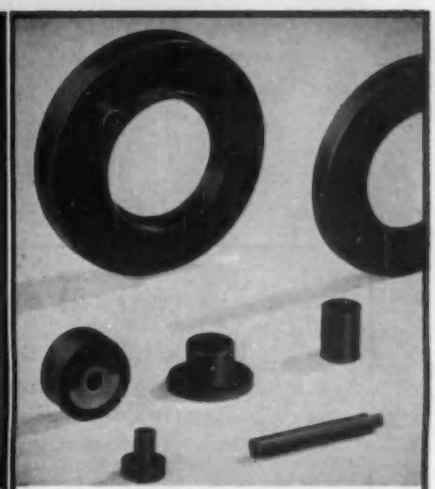
(GENERIC TERM FOR POLYMERS OF MONOCHLOROTRIFLUOROETHYLENE)



Intricately shaped electronic parts are readily molded from BAKELITE Fluorothene. They have excellent dielectric properties, zero moisture absorption, and high resistance to chemical attack. This male connector used in aviation electronic equipment has pins and center post molded in place.



Extruded wire covering of BAKELITE Fluorothene protects against corrosion, fungus, weathering, and impact, in addition to providing good dielectric properties over a broad temperature range. It is excellent for instrumentation control in chemical plants or wherever corrosive atmospheres are encountered.



Superior dielectric properties of BAKELITE Fluorothene at elevated temperatures make it an ideal material for these insulators and other parts used in high-frequency radio circuits. Excellent molding properties make it possible to produce these variously shaped parts to close tolerances.

Film made from BAKELITE Fluorothene, used as a wrapping for wire and electrical parts, provides excellent dielectric properties in combination with toughness and chemical resistance over a broad temperature range. It is also resistant to weather and corrosive atmospheres and will not absorb moisture.

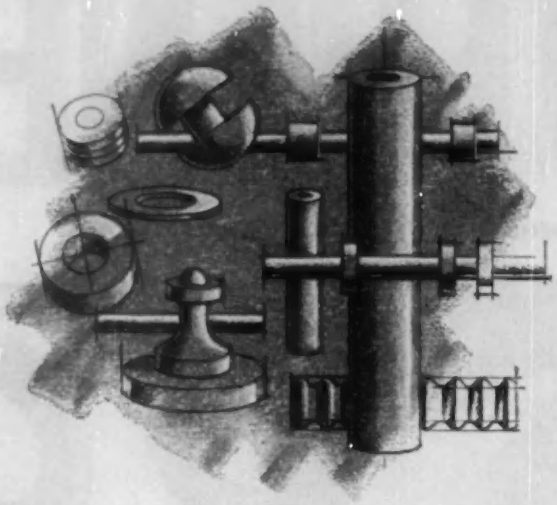
BAKELITE
BRAND
FLUOROTHENE

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

No need to settle for less than DIAMOND-HARD insulators and small parts!



New Centralab facilities cut cost of Grade L-5 Steatite Ceramic

NOW prices are lower than ever before on Centralab Steatite. So now you can enjoy its extra advantages — at substantial savings.

We're talking about Grade L-5 steatite — not slip-cast porcelain material or flowerpot clay. We're talking about Centralab's high-quality steatite that is harder than quartz — and provides low loss at high frequencies.

See for yourself that Centralab's new production equipment and methods can save you money on the small parts you use in volume, such as feed-throughs . . . coil forms . . . tubes . . . insulators . . . bobbins . . . igniter parts. Whatever their shape, whatever their size, ask us to quote on your requirements.

There's a gold-mine of know-how in Centralab's Ceramic Buyer's Guide, Bulletin 42-221. Refer to it in Sweet's Product Design File — or write for your personal copy.

Here's a typical example:

Shown actual size

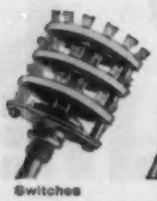
$5 or less per thousand for this precision feed-through

More proof that if it's a job for electronic components, it's a job for Centralab

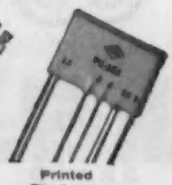
Centralab's advanced engineering continues to create the prototypes of the components industry

Volume Controls

Capacitors



Switches



Printed Electronic Circuits

Ceramics

Like to win a top-quality portable drill — with accessories?
Enter this month's
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Answer this question in 50 words, more or less: What business qualifications do you consider most important in a supplier?
A leading editor will pick the winner of this month's major prize.
Mail your entry to us before July 30.

†Nothing to buy. Employees of Centralab and their advertising agency not eligible. Duplicate prizes awarded in case of tie. Entries become the property of Centralab—none can be returned.

X-554

Centralab

A DIVISION OF GLOBE-UNION INC.

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SINCE 1922, INDUSTRY'S GREATEST SOURCE OF STANDARD AND SPECIAL ELECTRONIC COMPONENTS

Aluminum SHAPES

by ROLL FORMED

Aluminum shapes reduce production costs and eliminate waste. Let **ROLL FORMED** deliver your aluminum shapes notched and cut to length. **ROLL FORMED** shapes are uniform and accurate—made to your most rigid specifications. **ROLL FORMED** shapes are controlled through all phases of tool design, roll making and final production. Send us your blueprints for shapes in carbon, galvanized and stainless steel, copper, zinc, clad metals, as well as aluminum. Let us show you how our modern plant facilities can produce your sections at lower costs to you.

Write for Catalog No. 1053

ROLL FORMED PRODUCTS
COMPANY

MAIN OFFICE AND PLANT 3756 OAKWOOD AVE. • YOUNGSTOWN, OHIO

This young woman can easily lift this roll of L·O·F Glass Fibers' insulation. It contains 400 board feet and weighs only 16⅔ lbs.

Why L·O·F Glass Fibers' lightweight insulation has "unique design possibilities"

Design engineers tell us they consider L·O·F Glass Fibers' insulation "the insulation with unique design possibilities."

They value first, of course, its high thermal efficiency and sound-absorption characteristics. And they point out that either Microlite or L·O·F Super·Fine—the two blanket insulation materials made by L·O·F Glass Fibers Company—brings you these highly desirable advantages:

LIGHTWEIGHT—It reduces weight of insulated units.

SPACE REDUCING—It does a better insulating job in less space than most other materials require.

HANDLES EASILY because it's soft and pliable, and compresses readily into hard-to-reach spots, then springs back to original shape. Has unusually high tensile strength.

CLEAN AND SANITARY because it is made of inorganic glass fibers.

NONCORROSIVE—It has no effect on aluminum, steel or other commonly used construction materials.

RESISTS SETTLING when subjected to constant bumps, jarrings and vibration.

FIRE-RESISTANT—Glass fibers are noncombustible.

MOISTURE-RESISTANT—Noncellular fibers won't absorb moisture beyond a mere surface wetting.

EASY TO FABRICATE—Can be easily cut to any shape or size with knife or scissors. Can also be cut on regular die-cutting equipment. Is readily bent around curved surfaces and fitted into irregular areas.

MICROLITE

L·O·F GLASS FIBERS

SUPER·FINE

For further information on how L·O·F Glass Fibers' insulation can help you solve your design problems, contact our nearest office. Or write: L·O·F Glass Fibers Co., Dept. 4-75, 1810 Madison Ave., Toledo 1, Ohio.

L·O·F GLASS FIBERS COMPANY

TOLEDO 1, OHIO

Makers of glass fibers by the exclusive "Electronic-Extrusion" process.

new career openings

ANTENNA AND RADOME DESIGN ENGINEERS

Experience in airborne and/or radome design and development. Advanced degree in E.E.; mathematics or physics desirable. Previous experience in electro magnetic theory, knowledge of di-electric and ferrite materials advantageous. Work to consist of research, development, and design of airborne antennas, radomes, and antenna systems for high performance aircraft.

ELECTRONICS ENGINEERS

Degree in E.E. plus experience in airborne or its associated components. Component development with experience in circuitry and packaging techniques advantageous. Work will consist of cooling reliability and evaluation studies of electronic equipment.

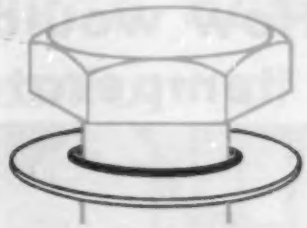
Write or apply

Engineering Personnel Office
Dept. A

NORTH AMERICAN AVIATION

Columbus 16, Ohio

end leakage...have lock washer action with Precision O Dyna-seals



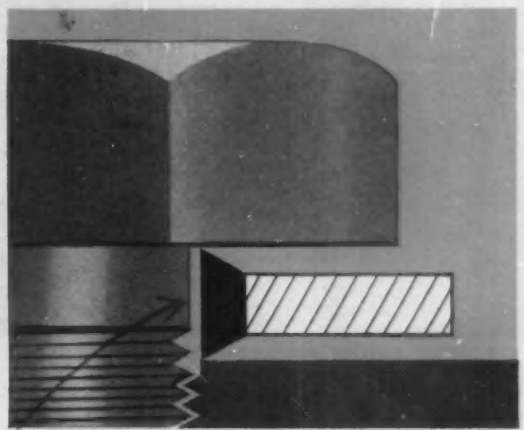
Seal up to 10,000 psi steady or pulsating pressure

Here is today's answer to leakage problems created by face-to-face sealing. Dyna-seals not only completely eliminate leakage but make possible important reductions in tooling, installation and maintenance costs.

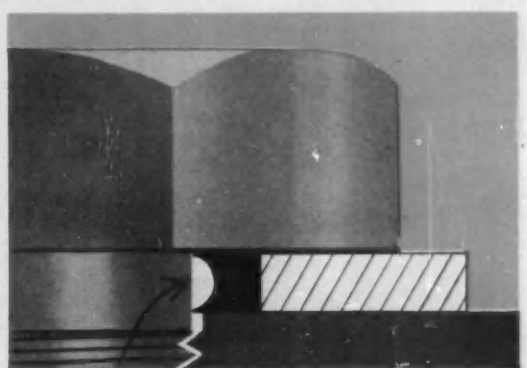
The secret of Dyna-seal success is a synthetic rubber sealing member, heat and pressure bonded to a steel washer. It supplies a positive lock washer action and reduces bolting torque. Under pressure, the flexing action of Dyna-seal assures a positive seal under all conditions—against water, gasses, petroleum products and many other fluids.

Dyna-seals permit face-to-face sealing with no grooves to cut or special machining of surface to be sealed. Here is simplicity in assembly that reduces fabrication costs and improves product appearance as well.

Use Dyna-seals on any flat surface under bolt or rivet heads, cap nuts, flanges, special fittings, etc. Let a Precision engineer work with you and demonstrate the advantages of putting Dyna-seals into your products.



Note flare of rubber sealing member. When compressed under any type of bolt, flange or screw, it provides positive lock washer action, and reduces bolting torque.



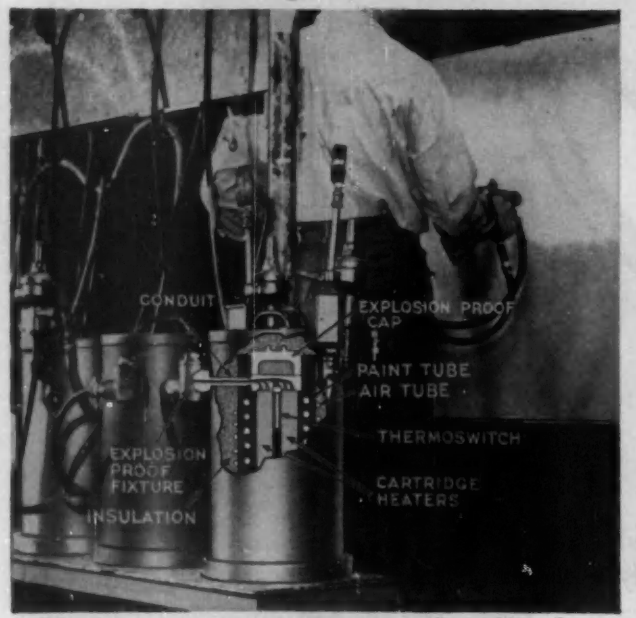
When pressure of bolt head is applied, sealing lips are forced against surface, forming a convex shape opposing steady or pulsating pressure. Dyna-seal provides positive sealing against leakage.

Precision Rubber Products
CORPORATION
"O" Ring and Dyna-seal Specialists

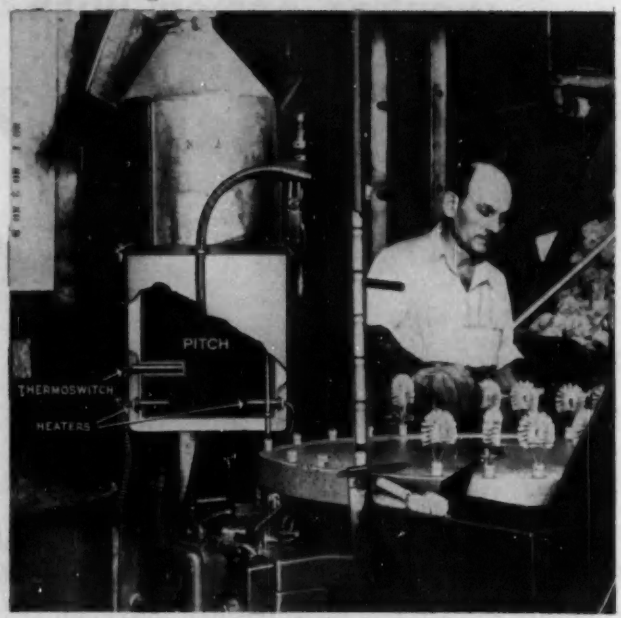
Dept 3 Oakridge Drive, Dayton 7, Ohio

Canadian Plant at: Ste. Therese de Blainville, Quebec

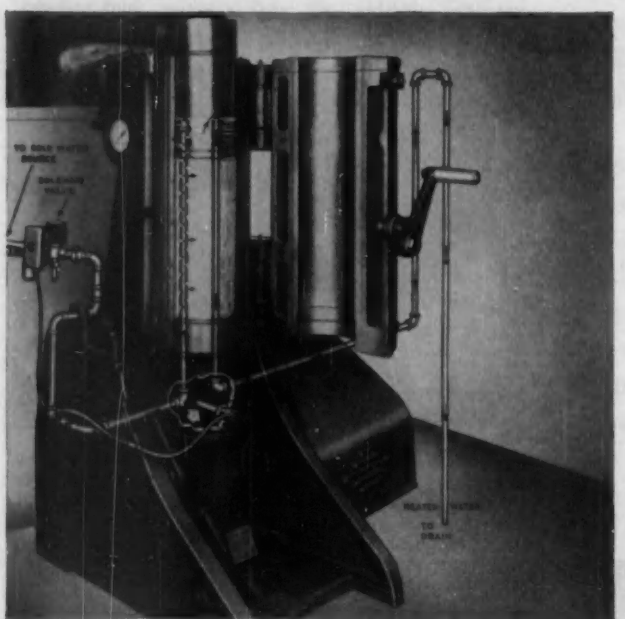
How would you solve these tricky temperature control problems?



1. KEEPING A PAINT HEATER EFFICIENT was the problem. It was solved with the help of a Fenwal heavy duty block THERMOSWITCH® unit. Heat from a 2000-watt source is accurately held at 150F — for top efficiency. Users just plug it in, forget it. THERMOSWITCH unit is attached to explosion-proof block, as shown in diagram.



2. PROTECTING MACHINERY. Engineers wanted to prevent motor damage to automatic brush assembly equipment by starting the operation shortly *before* the sealing compound (pitch) reached the liquid stage. Upon Fenwal advice an inverse type THERMOSWITCH unit was installed to close circuit when pitch temperature reaches 180F. Circuit opens *only should* pitch heaters fail.



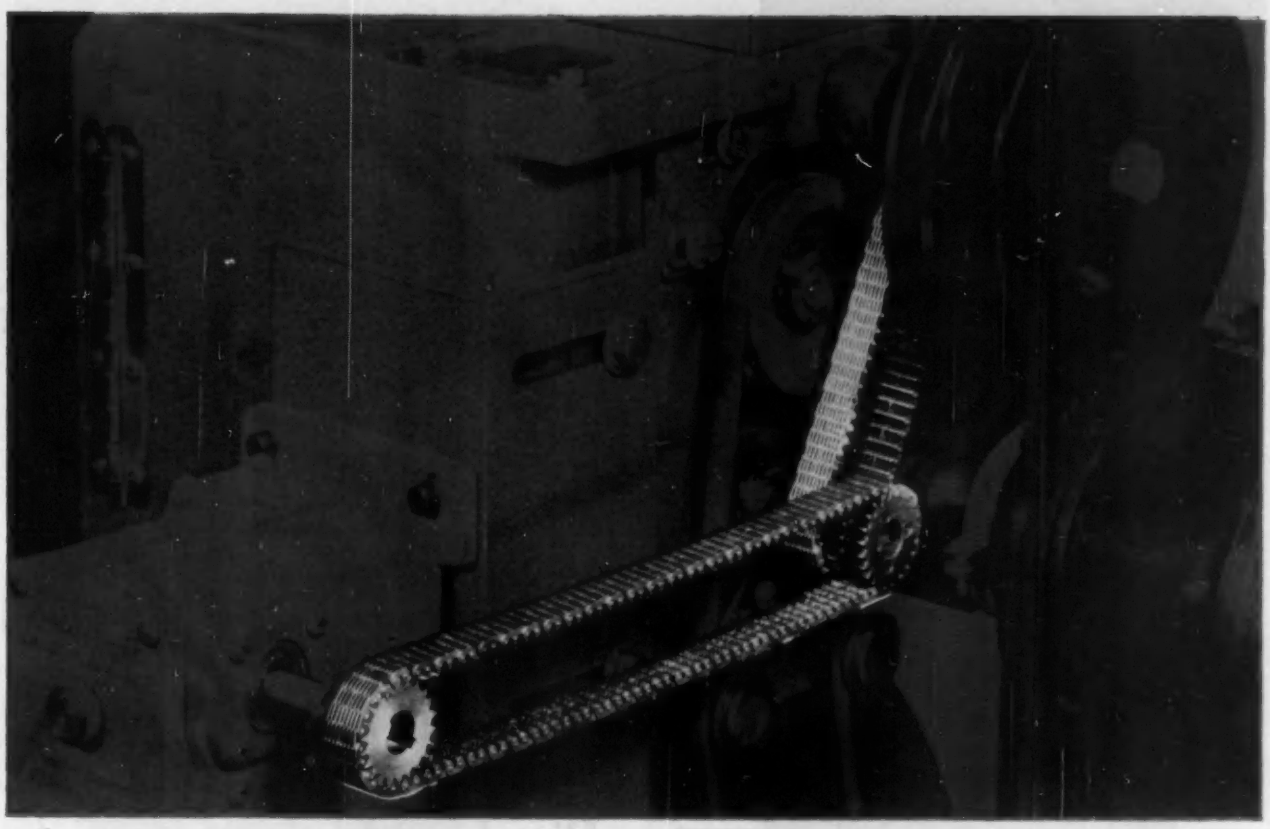
3. COOLING PRINTING PLATES. If printing plates cool too fast, they shrink — if too slow, they become porous. Reject plates were practically eliminated when a solenoid water valve was substituted for a hand valve — with a Fenwal THERMOSWITCH unit guarding the water temperature closely and operating the valve whenever the set point was passed. THERMOSWITCH shell itself "senses" change.

4. FREE CATALOG brings you complete data on the unique THERMOSWITCH unit. More details on problems discussed here if you want them. Fenwal engineers are always glad to help on special temperature control problems involving heat, humidity, pressure and other variables. Write **Fenwal Incorporated, 27 Pleasant St., Ashland, Mass.**

Fenwal **THERMOSWITCH®**

Controls Temperature — Precisely

Morse Silent Chain Drives assure positive synchronization of 3-D movie projector



Perfect synchronization of two projected images is used to create an illusion of depth in the Natural Vision 3-D process. To achieve this, Motiograph, Inc., Chicago, Illinois, uses a Morse silent chain interlock between two projectors.

Morse Silent Chain Drives had been used by Motiograph for over 15 years in other film applications. It was only natural that they should turn to Morse for the delicate job of 3-D synchronization. Morse Silent Chain Drives give smooth, positive action; reduce slippage losses; and load on shaft bearings. Exclusive Rocker-Joint construction assures long chain life, safe operation at high speeds.

Check the Advantages of Morse Silent Chain Drives:

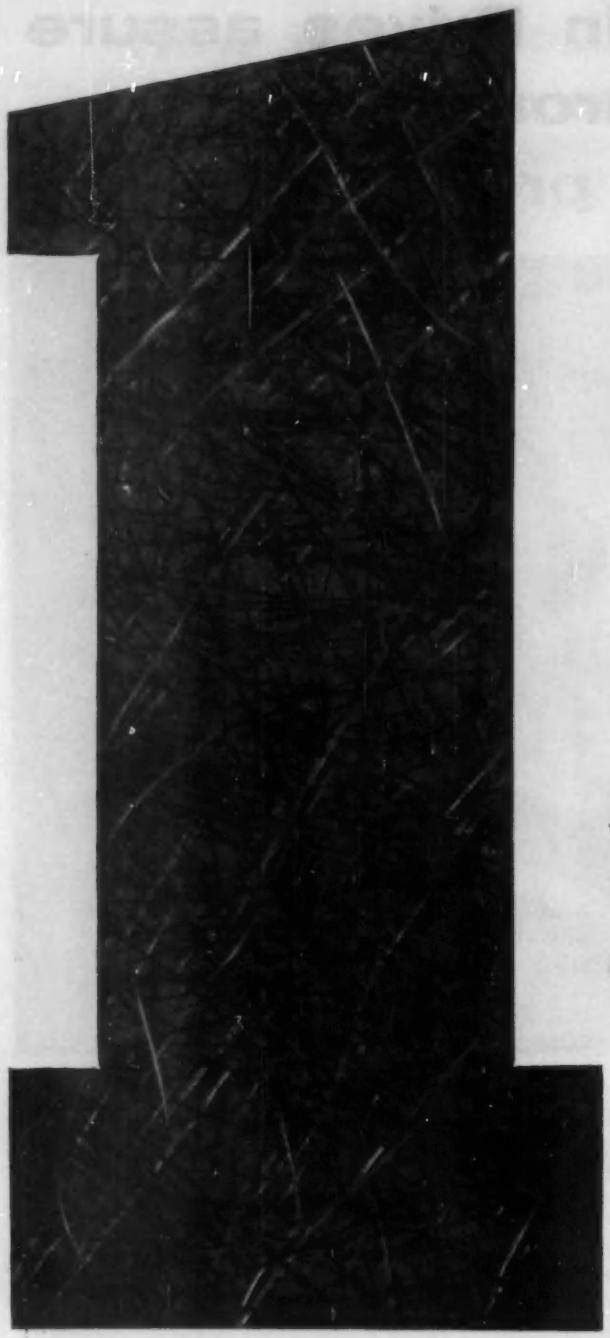
- Long service life
- Low cost
- Compact and dependable
- 99.4% efficient
- Easy to assemble, disassemble
- Require minimum maintenance

Adaptable Morse Silent Chain Drives solve problems of mechanical synchronization.

Check Morse for information on the advantages of Silent Chain Drives for your own applications—as well as other precision-built Morse products: Morse Roller Chain, Sprockets, Couplings, Cable Chain, and Clutches.

MORSE CHAIN COMPANY, INDUSTRIAL SALES DIVISION, ITHACA, NEW YORK.

MORSE BW **CHAINS, CLUTCHES, AND COUPLINGS**



Finest quality reinforcement for your component parts . . .

Pittsburgh Fiber Glass

In the field of fiber glass reinforcements for plastics or rubber components, Pittsburgh Fiber Glass has rapidly established a reputation for highest quality material. For both lowering manufacturing costs, and adding higher strength properties, many manufacturers choose PPG Fiber Glass roving or cloth and mat woven from PPG Fiber Glass.

Widely used to add strength and dimensional stability to a wide variety of rubber, plastics or paper products parts, PPG Fiber Glass also adds excellent dielectric strength to electrical housings and structural parts when it is used as reinforcing cloths in laminates. In wire and cable sleeving and tubing, too, PPG Fiber Glass adds new wear and insulation qualities.

Check into the profitable facts on PPG Fiber Glass for use in your product's design and construction—you can obtain complete information and technical staff assistance through our executive office or district sales offices in Charlotte, Chicago, Cincinnati, Cleveland, Detroit, Houston, Los Angeles, New York, Philadelphia or St. Louis. Pittsburgh Plate Glass Company, Fiber Glass Division, One Gateway Center, Pittsburgh 22, Pennsylvania.

FIBER PG GLASS PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS

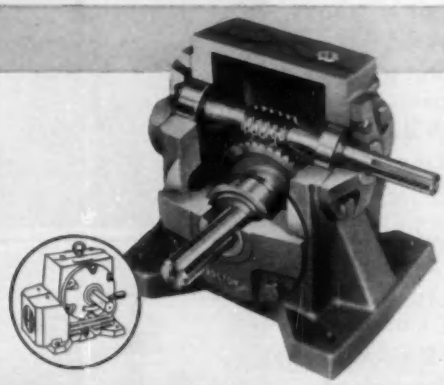
PITTSBURGH PLATE GLASS COMPANY

THE NEW BOSTON GEAR 100 SERIES SPEED REDUCTION UNITS

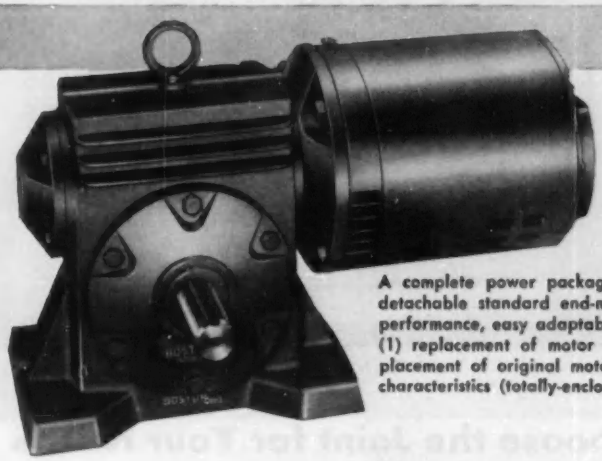
Every feature you want- any model you need - FROM STOCK

REDUCTORS

CERTIFIED ratings
NEW space-saving design
NEW clean contours
NEW gearing efficiency
NEW cooling fins
FAN-COOLING optional on larger sizes



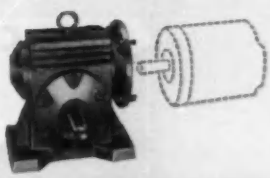
RATIOMOTORS



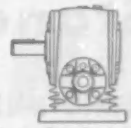
— all new features of Reductors plus NEW *Combination* CONSTRUCTION

A complete power package — gear reduction unit and easily detachable standard end-mounted motor — combined for peak performance, easy adaptability, big maintenance savings. Permits (1) replacement of motor without disturbing gear unit. (2) Replacement of original motor at any time with motor of special characteristics (totally-enclosed, etc.).

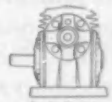
FLANGED REDUCTORS The Ratiomotor gear reduction unit, supplied *without* motor. You buy and attach the motor of your own choice.



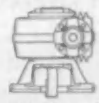
Certified MAXIMUM HORSEPOWER PER DOLLAR



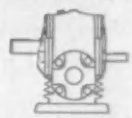
Horizontal Right Angle Drive Worm gear on top



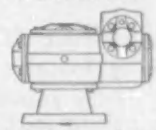
Horizontal Right Angle Drive Worm gear under



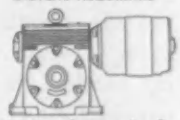
Vertical Right Angle Drive



Horizontal Parallel Drive Double Reduction

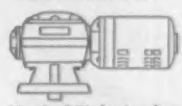


Vertical Right Angle Drive Double Reduction

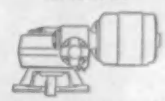


Horizontal Right Angle Ratiomotor

Horizontal Parallel Ratiomotor Double Reduction



Vertical Right Angle Ratiomotor



Vertical Right Angle Ratiomotor Double Reduction

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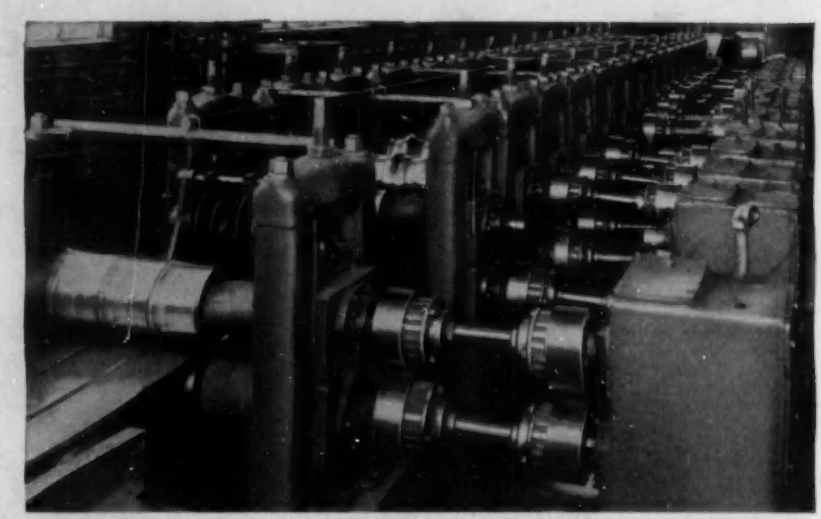
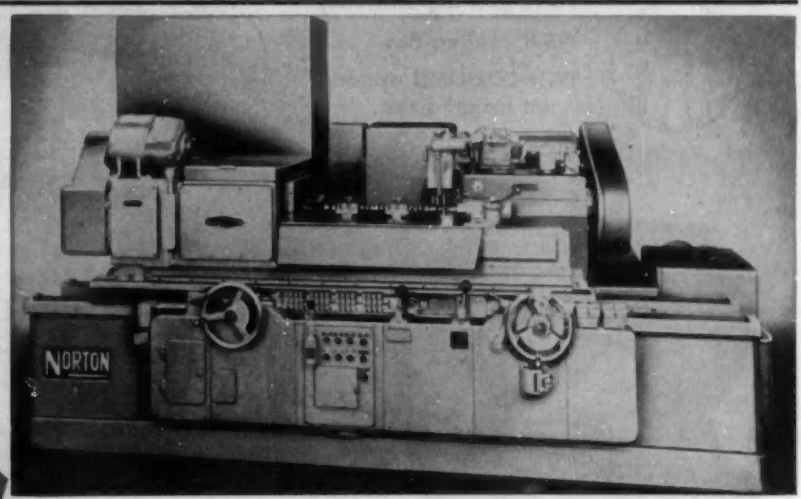
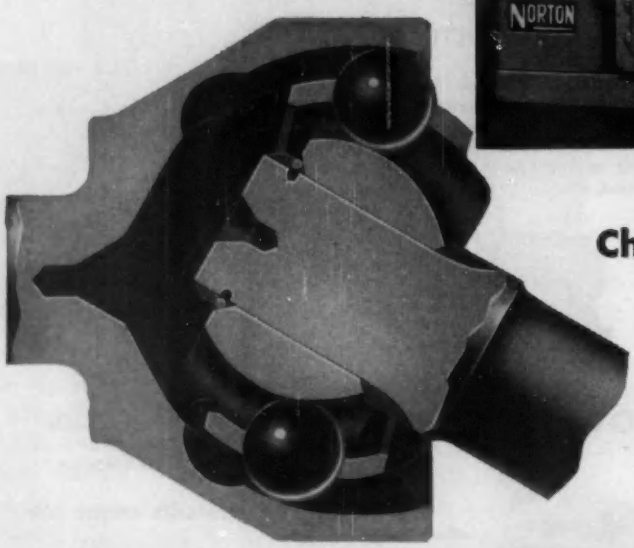
How Long-Lived Rzeppa Joints Stand Up Under Heaviest Drive Loads

ROLLING MILL at Detroit Steel Products Company has licked a severe joint breakage problem with Rzeppa Constant Velocity Universal Joints. Breakage first occurred, just six hours after mill began operation, at the finishing end—where most stresses are applied (foreground). A replacement of the same type also failed—as did other joints along the line as time passed. Five years ago the company began replacing breakages with Rzeppas. *To date not a single Rzeppa has broken.*



MACHINE TOOLS: Norton Company installs Rzeppa Constant Velocity Joints in No. 2 CAM-O-MATIC Grinders for a long life of precision operation. "Rzeppa Joints provide smooth operation, minimum backlash and constant rotating motion regardless of angular motion," says Norton.





Choose the Joint for Your Needs

Rzeppa Constant Velocity Universal Joints are built in both the low angle (to 18°) high speed, disc-type joint (used in applications above), and high angle (to 35°) low speed, bell-type joint. Internal construction of both joints is identical with interchangeable internal parts.

Whatever your application, specify the joint that brings you ruggedness and long life with maximum capacity and true constant rotating motion.

Send for latest catalog.

RZEPPA Constant Velocity **UNIVERSAL JOINTS**
(pronounced "Sheppa")

THE GEAR GRINDING MACHINE CO.
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Detroit 11, Michigan

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RESEARCH
and
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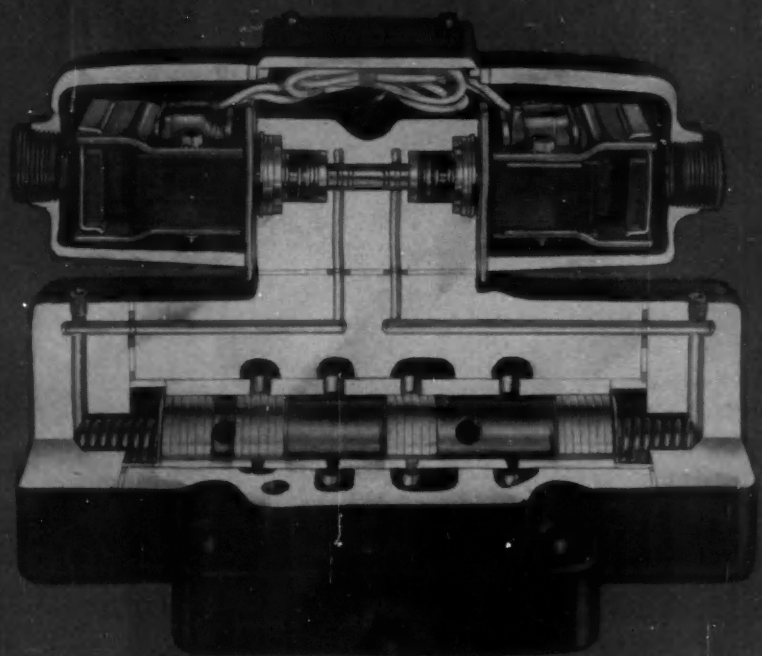
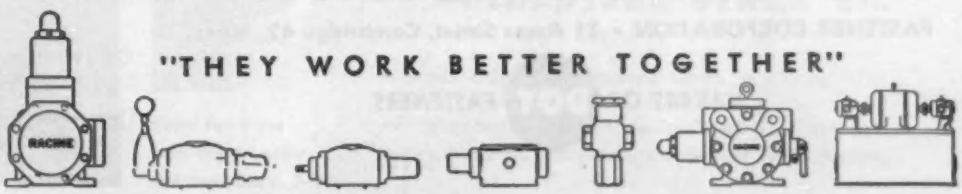


Balanced Piston -- Sleeve Type -- 2000 psi Working Pressure

This design offers Solenoid Control, Pilot Operation, Subplate mounting, and allows unusual versatility with conversion to either spring centered, spring offset, or no spring. Solenoids are enclosed and secured to the valve in removable dust proof covers. Electrical operation is prevented when the covers are not in place. This feature promotes safety, and contributes to low maintenance.

Large openings permit a maximum flow of oil through the valve at a minimum pressure drop. This valve conforms to J. I. C. specifications and standards.

Write for catalog giving complete details and features. Address **RACINE HYDRAULICS & MACHINERY, INC.,** 2072 Albert St., Racine, Wisconsin.



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that locks and seals itself

⅜" HEX. #10

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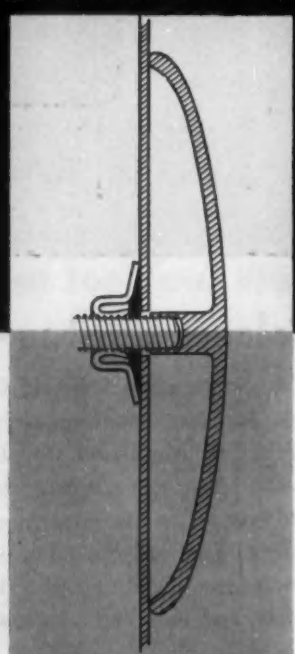
FREE SPINNING — nut spins easily onto bolt . . . sealing ring does not drag until it comes into contact with surfaces to be fastened.

STRONG — multiple threads ensure high torque and tensile strength.

TWO FLANGE SIZES — ¾" flange available with notches for extra locking power and positive grounding (shoulders bite into finish of parts to be fastened and prevent nut from vibrating loose). Both ¾" and ⅝" flange available with or without sealing ring. (Locking type heat treated for extra tension.)



Note how cupped base of nut allows tapped portion of cast or molded part to project through sheet metal mounting structure in typical application.

For further information on WASHER NUTS or any other problems involving special fasteners or self-fastening devices, contact your nearest United-Carr representative or write us direct.

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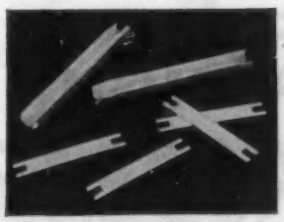
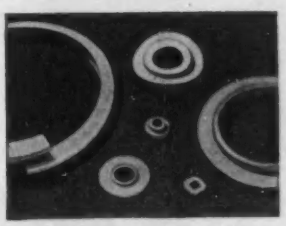
what's this paper-thin material that's ending design problems?

Thin Fibre supports man's full weight. These corrugated sheets are used in duct forms for cooling electrical transformers—where a combination of good electrical properties, high mechanical strength and rigidity is essential.



Suture Reels for Surgical Use must withstand immersion in alcohol or formaldehyde until used. Easy forming, slitting and chemical inertness are other advantages of vulcanized fibre.



An Endless Variety of Washers and other punched parts can be made from vulcanized fibre. Machining steps include forming, punching, shaving, swedging, contouring.

Retaining Cups of Vulcanized Fibre are used to hold in place other insulating materials or adhesives. Easily drawn from thin fibre, these cups replace expensive molded plastic parts.

You've seen it before in critical applications. You may even have used it yourself without realizing its full potentials. Since 1873, its unmatched combination of properties has unscrambled thousands of design puzzles.

It's far more than an insulating material—although you can't buy a better insulator at the price. It's one of the strongest materials known—per unit of weight. It's tough, hard, resilient, resistant to wear and corrosion, and weighs only half as much as aluminum. And it's easy to draw, form or machine to virtually any shape.

Its name is *National Vulcanized Fibre*—the original time-tested plastic. Its uses are legion. Besides the parts shown here, it goes into such rough-duty products as textile-shuttle armor, abrasive discs, athletic guards, rail joint insulation, gears and cams. If there's a design problem defying you, learn how to lick it with this versatile material. Our new 16-page General Catalog—considered a handbook for designers—is yours for the asking.

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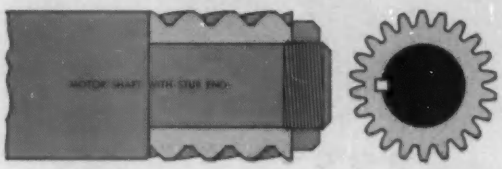
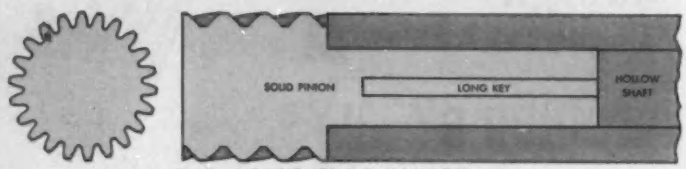
In your opinion, which pinion?

. . . for longest life in a gearmotor



ORDINARY SHELL TYPE PINION



U. S. SOLID TYPE PINION

In an internally geared motor the pinion on the motor shaft is the vital link between motor and gearing. It's the fastest, but smallest gear, so it must be extra strong, free from vibration and forever tight. Now compare the U. S. Syncrogear motor pinion with the ordinary type. Note the extra large section area of the U. S. design. It has a long solid shank that anchors into the motor's hollow shaft, whereas the ordinary shell type has a small section area, short keyed.

Obviously the U. S. design is most substantial, longer lasting, more resistant to deflection and can carry high speed loads far more safely than common designs. All the gears are deep-hardened and shaved to exact tolerances in the U. S. plants.

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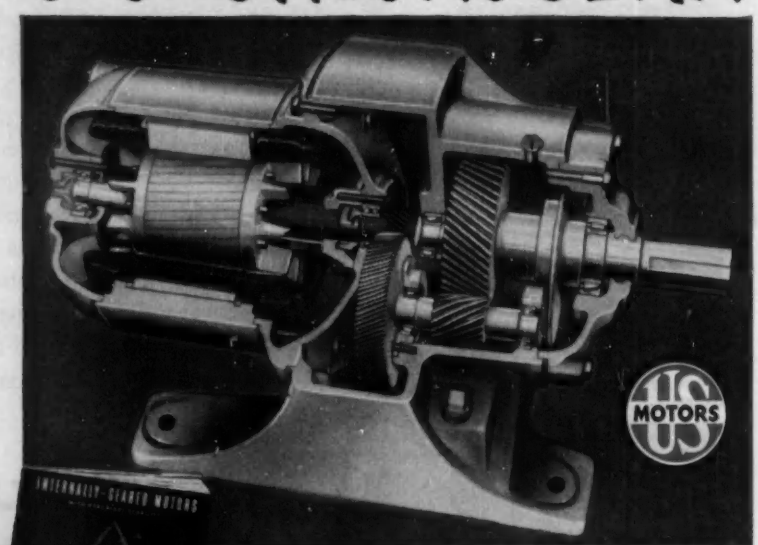
THE ONLY MOTOR WITH A

BUILT-IN PINION

U. S. SYNCROGEAR



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Interesting multi-colored Booklet presents engineering facts you should know about geared motors, and illustrates the various U. S. Syncrogear types. Mail the Coupon for a copy. No obligation.

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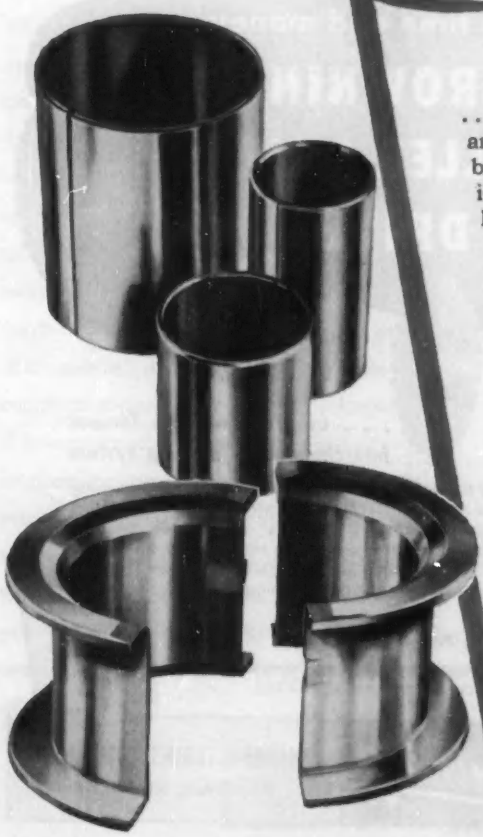

The sleeve bearing is basic in principle . . . for most applications man's genius has never invented any device to replace it. For instance, every internal combustion engine is dependent on it, and the majority of industrial equipment is, too. But modern requirements, high speeds, higher loads, and changing designs have called for new sleeve bearings. Johnson Bronze, alert to the demands of new engineering trends, is producing Johnson Modernized Sleeve Bearings, capable of giving the utmost service under these modern conditions. Aluminum bonded to steel is one of them. Copper-lead bronze-on-steel is another. New materials, new combinations of materials and new designs are meeting many new requirements. If you have a specific sleeve bearing problem, perhaps a Johnson engineer can help you. Write for an appointment.

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Sleeve-Type

JOHNSON BRONZE PRODUCES ALL TYPES OF SLEEVE BEARINGS: ALUMINUM-ON-STEEL • CAST ALUMINUM ALLOY • BRONZE-ON-STEEL, copper lead • STEEL BACK, babbitt lined • BRONZE BACK, babbitt lined • CAST BRONZE, plain or graphited • SHEET BRONZE, plain or graphited • LEDALOYL powder metallurgy

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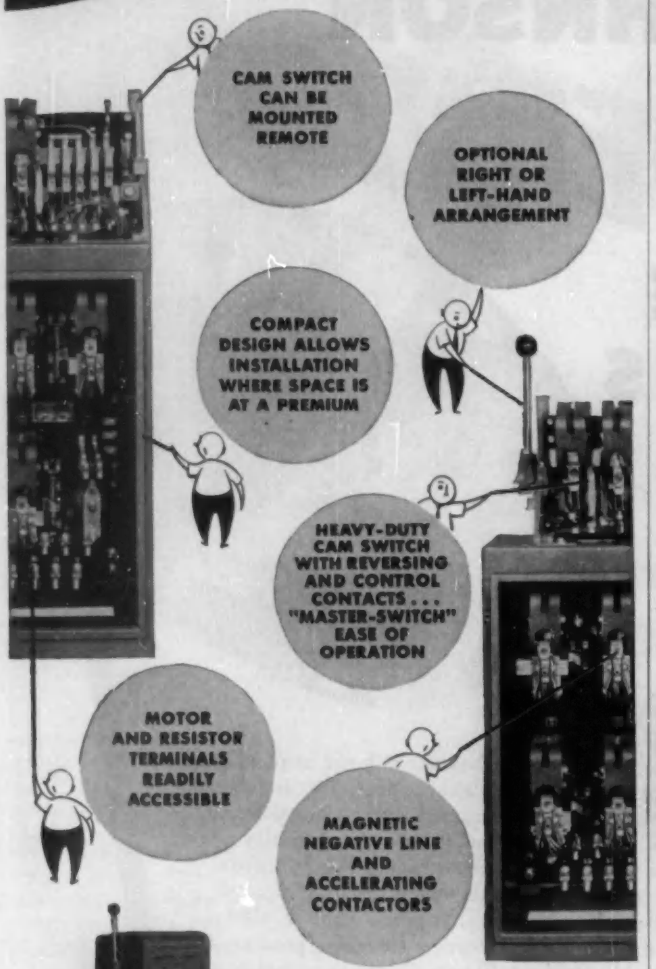
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HEAVY-DUTY CAM SWITCH WITH REVERSING AND CONTROL CONTACTS . . . "MASTER-SWITCH" EASE OF OPERATION
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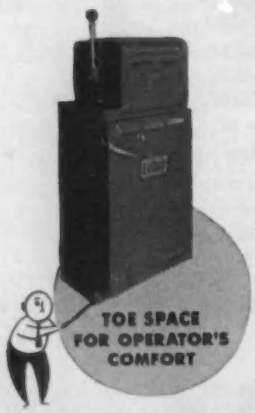

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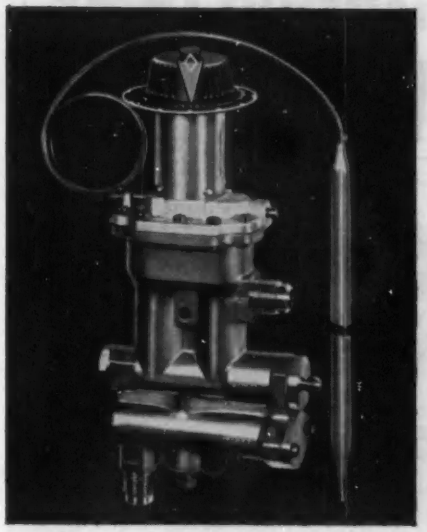

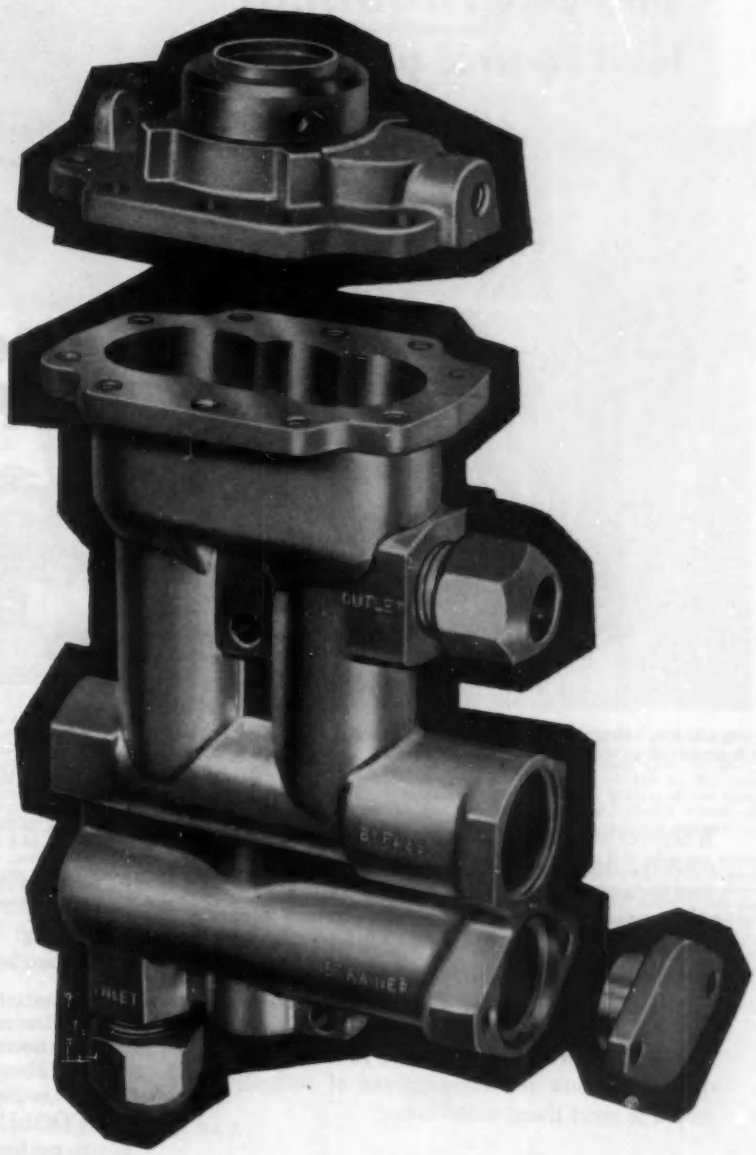

One of the finest thermostat control mechanisms for year-around air-conditioning systems is the automatic SELECTAFLOW, a product of the Detroit Controls Corporation. To maintain the high quality of this efficient unit and at the same time speed up and simplify assembly, the body, bonnet and side cover are being forged and completely machined to close tolerances by the Mueller Brass Co. In all, thirty-four machining and finishing operations are performed. This is but one more example of how Mueller Brass Co. machined forgings have improved a product and speeded production. With a wide range of copper-base alloys for forgings, a tremendous background of product engineering, and facilities for precision finish machining, the Mueller Brass Co. can supply machined brass or bronze forgings to *your exact specifications*. It will pay you to consider Mueller Brass Co. forgings for your new or redesigned products. Write us for full color catalog and technical information.

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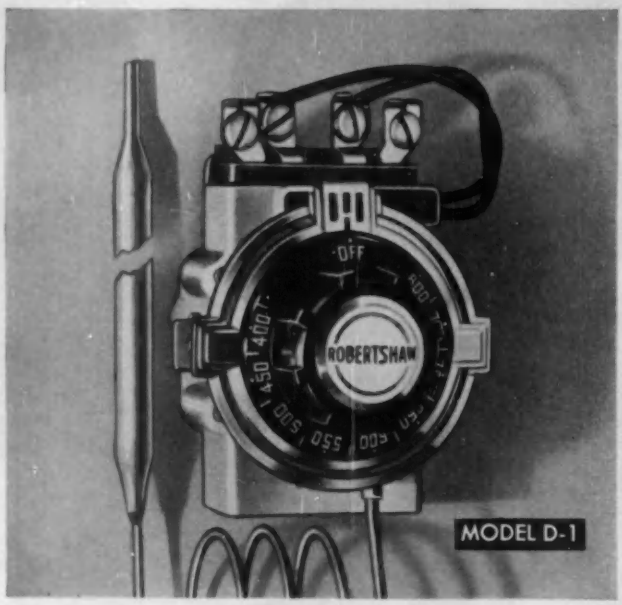
with your TOUGHEST heat control problems!



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Wherever you can use help in controlling heat... with positive, dependable thermostatic controls... you'll find it pays to turn to Robertshaw® controls. You can select ruggedly built controls of extreme accuracy and sensitivity, both surface and immersion types to meet a wide range of specific requirements, including single and double pole; single and double throw; single and double circuit; with and without limit switches. For a full discussion of your own exact requirements and recommendations of controls best suited to meet them, write today.

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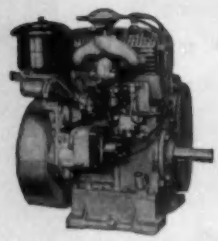
WISCONSIN-POWERED *Self-Propelled* Grain Swather



This is the Model TF 2-cylinder Wisconsin Heavy-Duty Air-Cooled Engine that supplies complete power for the Owatonna Grain Swather illustrated above—3¼" bore x 3¼" stroke, 53.9 cu. in. displ., 8.7 to 14.6 hp., 1400 to 2600 rpm. Larger size swathers are powered by the Model VF4 V-type, 4-cylinder Wisconsin Engine.

Typical of the practical ingenuity employed by farm equipment designers and builders for the most advantageous utilization of engine power is this Owatonna Grain Swather, made by Owatonna Mfg. Co., Owatonna, Minn.

A unique feature of this Center-Delivery Grain Swather is that it opens up all types of grain fields without running down standing grain. Mechanically operated aprons at both ends of the machine carry the grain, as cut, to the center opening, depositing it in a compact, uniform swath for clean, easy combining. The floating cutter bar extends over the entire length of the machine, forward of the wheels.

A remarkable feature of this equipment is that an engine as small as a 2-cylinder Wisconsin furnishes the necessary power both for *propelling* and *operating* this big machine. It's an assignment that calls for heavy-duty Lugging Power and foolproof AIR-COOLING at temperatures up to 140° F. Here is a perfect example of *Power to Fit the Machine, Power to Fit the Job!*

Wisconsin Air-Cooled Engines are available in 12 sizes in 4-cycle single cylinder, 2- and 4-cylinder models, in a 3 to 36 hp. range.

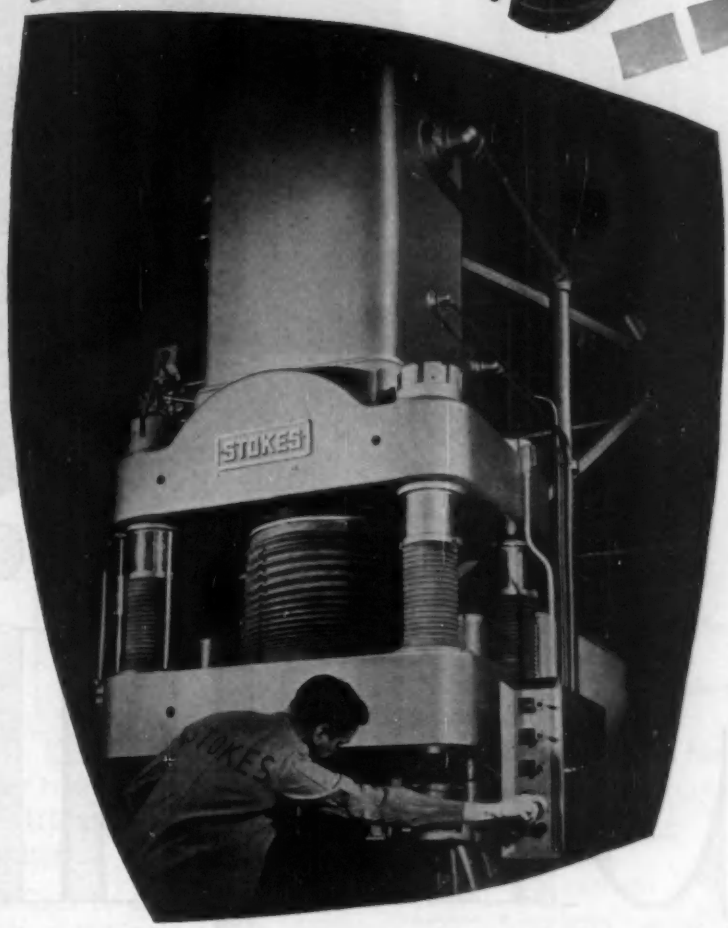
WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

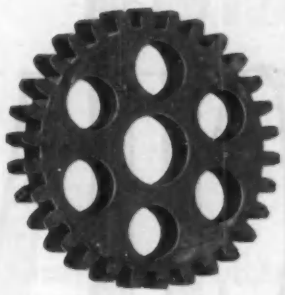
MILWAUKEE 46, WISCONSIN

A valve disc sleeve used in the air release mechanism of a Neptune Red Seal petroleum meter was originally made of brass rod stock, then of die-cast zinc (which proved unsatisfactory) and now of powdered brass. Tolerances are ±.001" on two diameters. The part costs no more than the unsatisfactory die casting and approximately ⅓ that of the machined part.

This oil pump rotor is used in several IBM machines. Saving in cost as compared with machined parts, says IBM, is 84%! Total tolerances of .001" and .002" are required. Powder metal processing eliminates all machining operations, which previously required 20 hours per 100 pieces.



Making this intermediate wringer-drive gear of iron and copper powder saves its user, the Whirlpool Corporation, St. Joseph, Michigan, up to $20,000 per year. The part was formerly made from a ⅜" blank which was pierced, flattened, machined for teeth; wire brushed for burr. Tolerances on the powder metal part are identical with those obtained by machining.



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Stokes has over thirty years' experience in making presses *specifically* for powder metal processing. Stokes engineers are recognized for their broad contributions to the growing success of powder metal processing... will gladly contribute their experience to manufacturers interested in powder metal processing as a means of cutting costs and improving products.

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The parts illustrated on this page are made by the Presmet Corporation, Worcester, Mass., custom maker of high-precision powder metal parts... like most producers of powder metal parts, a user of Stokes powder metal presses.

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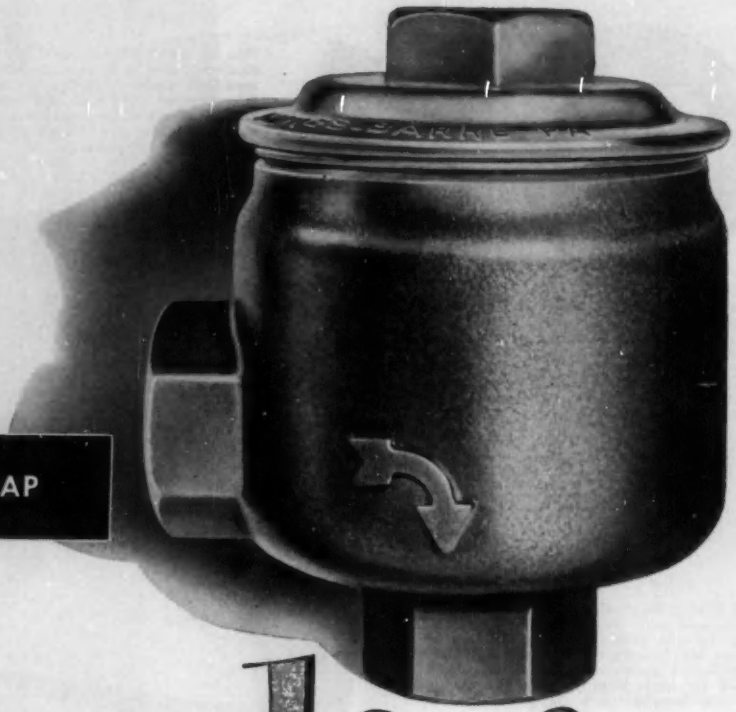
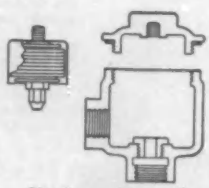


STEAM TRAP

Simplicity



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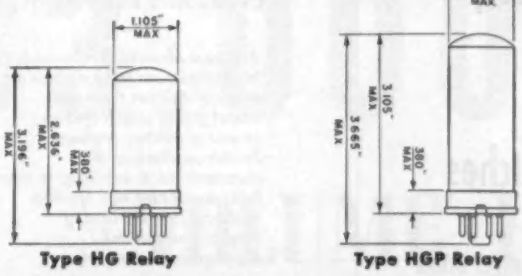

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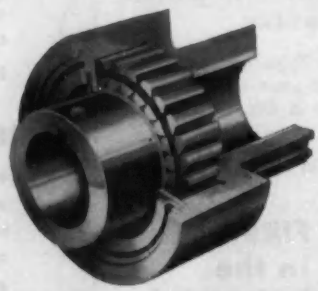

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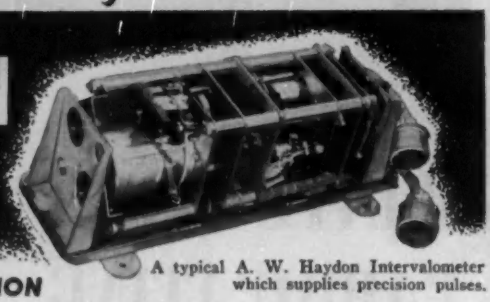

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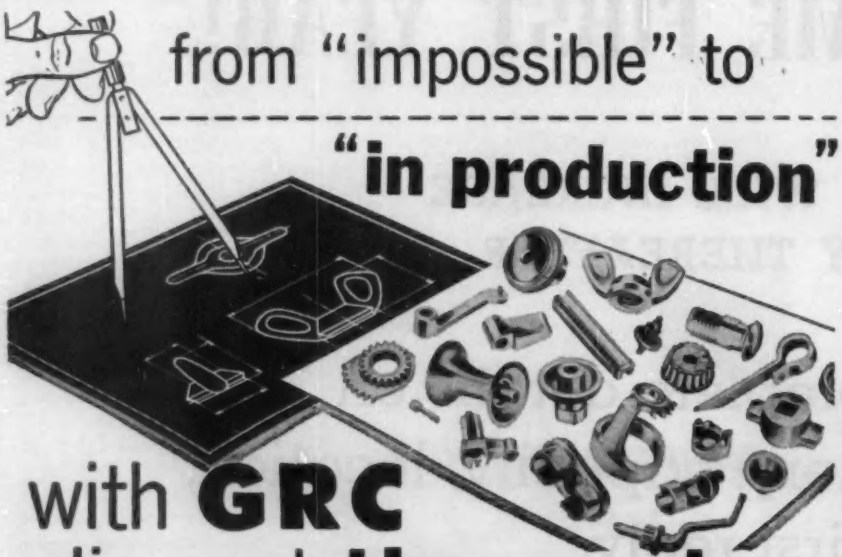

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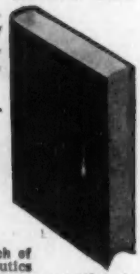

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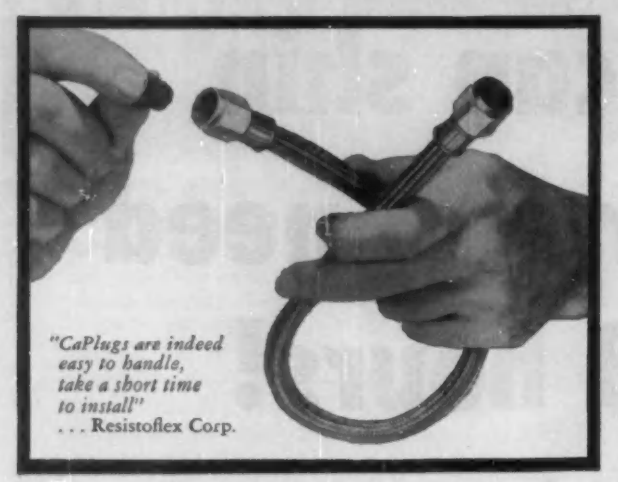

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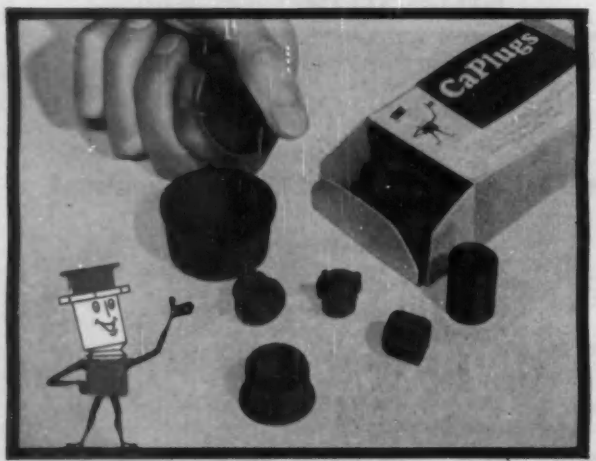

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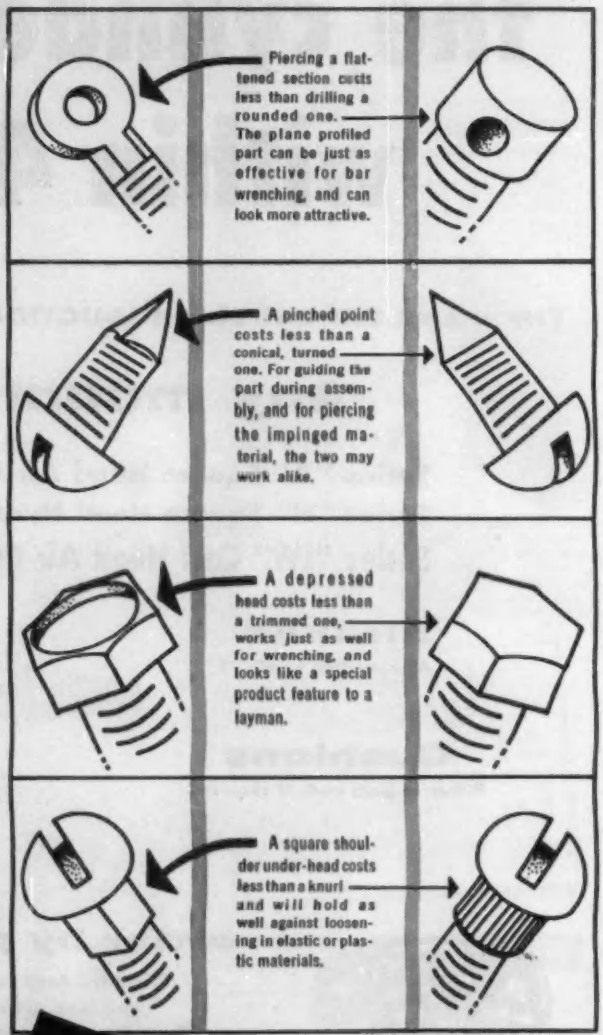
Piercing a flattened section costs less than drilling a rounded one. The plane profiled part can be just as effective for bar wrenching, and can look more attractive.
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REPRINTS *of this chart are available on request for use in drafting and purchasing departments.*

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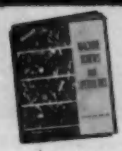

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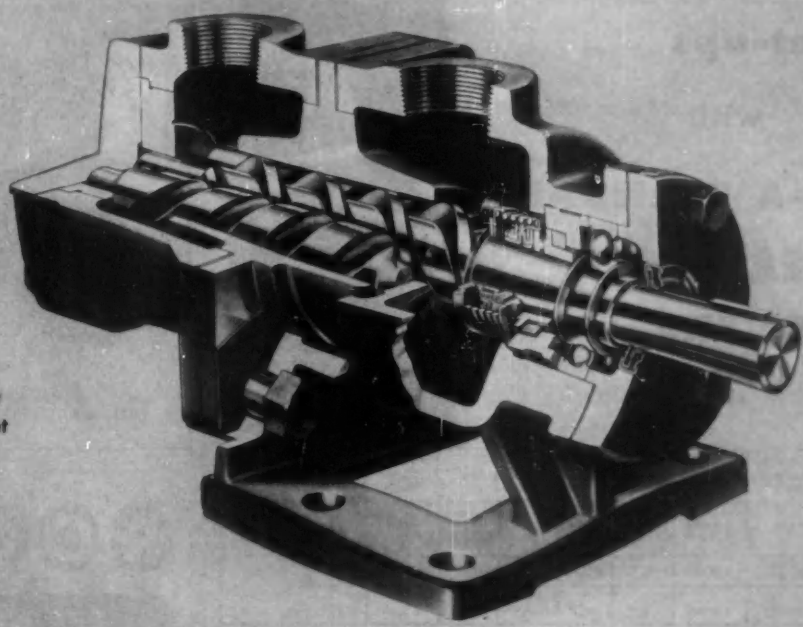

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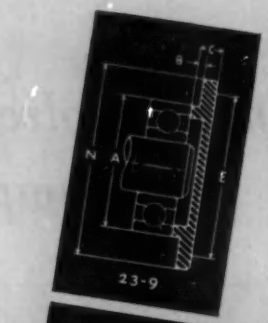

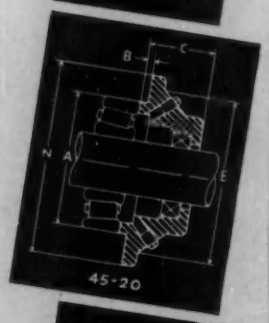

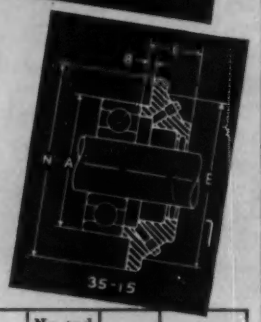

Description	"A" Bearing O.D.	"B" Depth Rabbet	"C"	"E" Bolt Circle	"N"	No. and Size Bolts	Shaft	O.D. Oil Seal
#23-9	2.2500	1/8"	7/16"	3"	LUG TYPE	4 3/8"	—	—
#45-20	5.0000	3/16"	2 1/4"	6"	7"	6 1/2"	2 1/8"	3.555
#35-25	6.2992	1/4"	2 1/16"	7 1/2"	8 3/4"	6 5/8"	3 13/16"	FELT 3/8" x 5/16"

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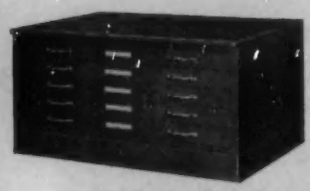

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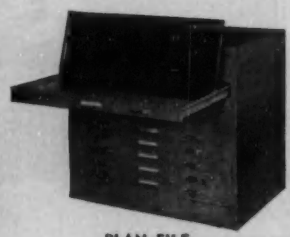

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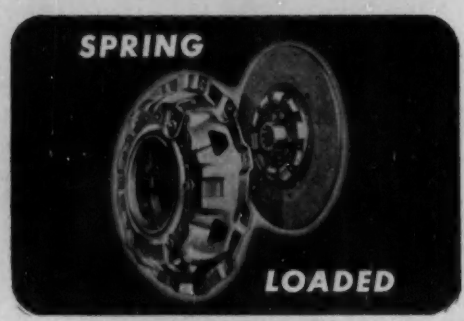

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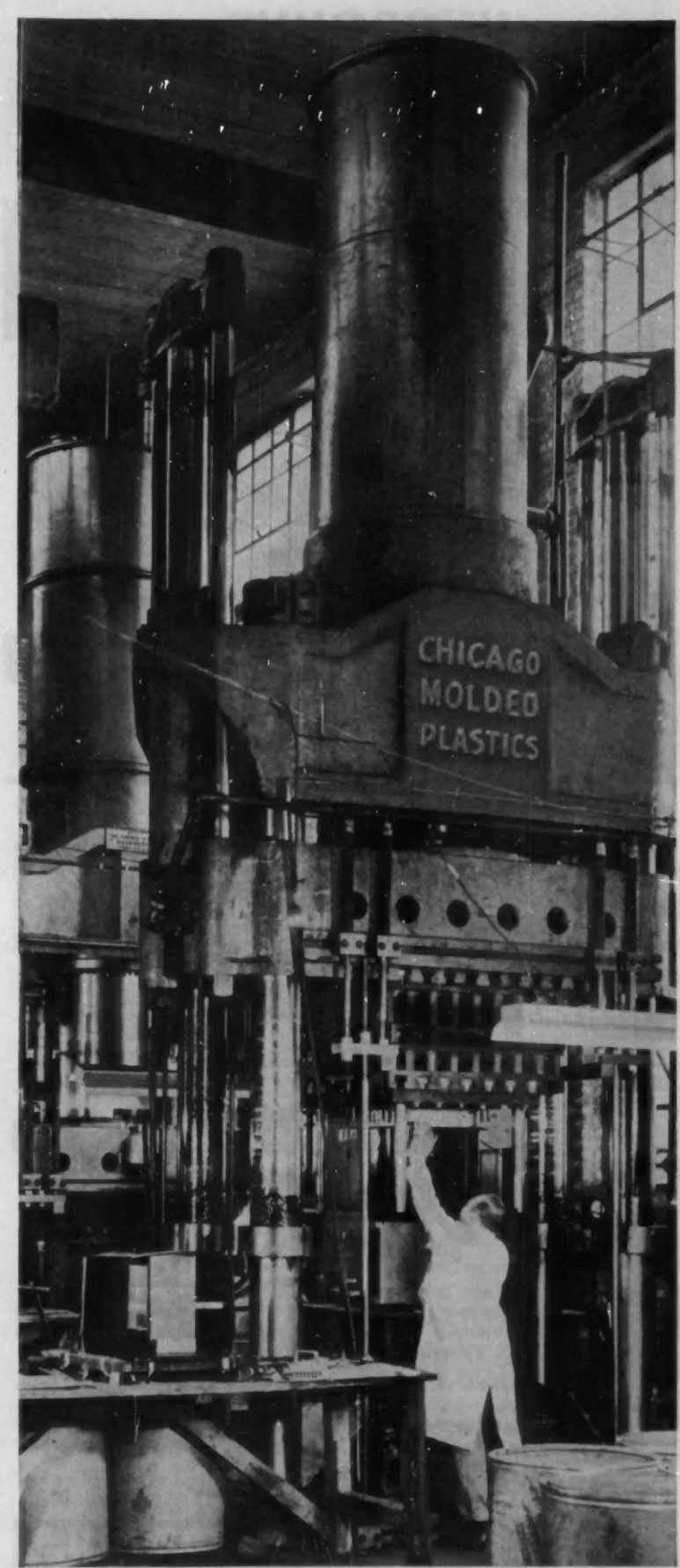
CLUTCHES



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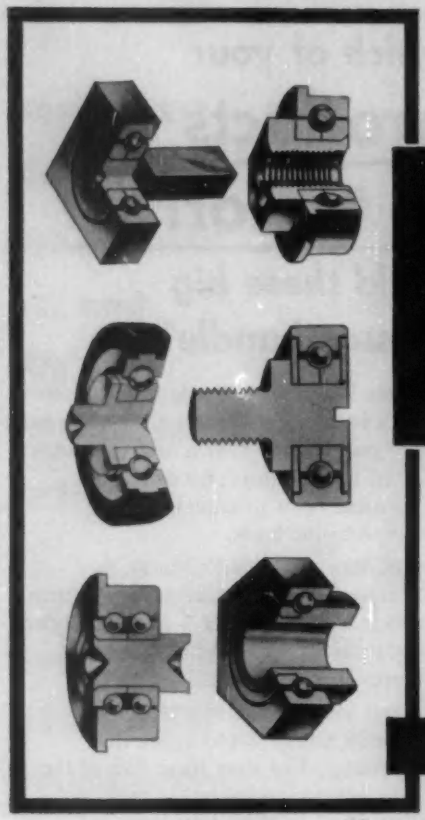

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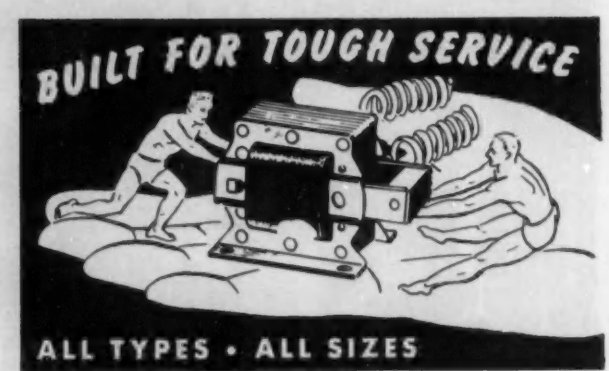

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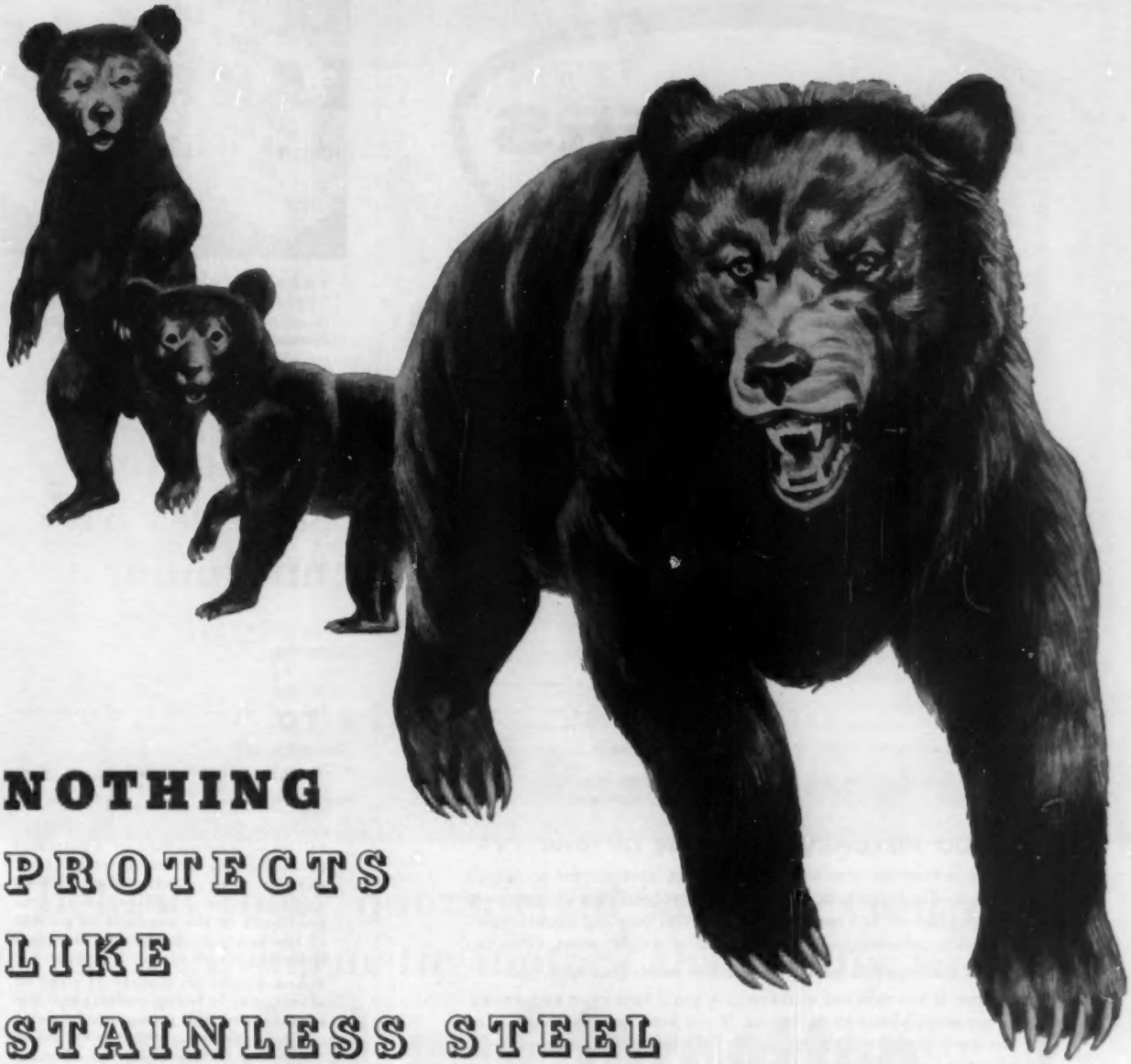

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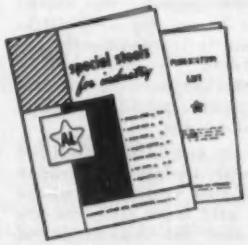

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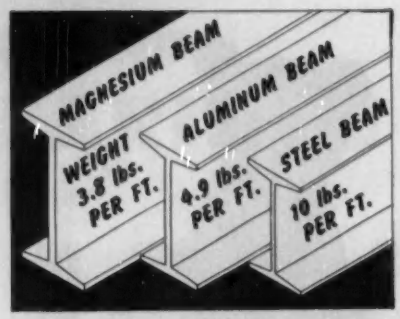

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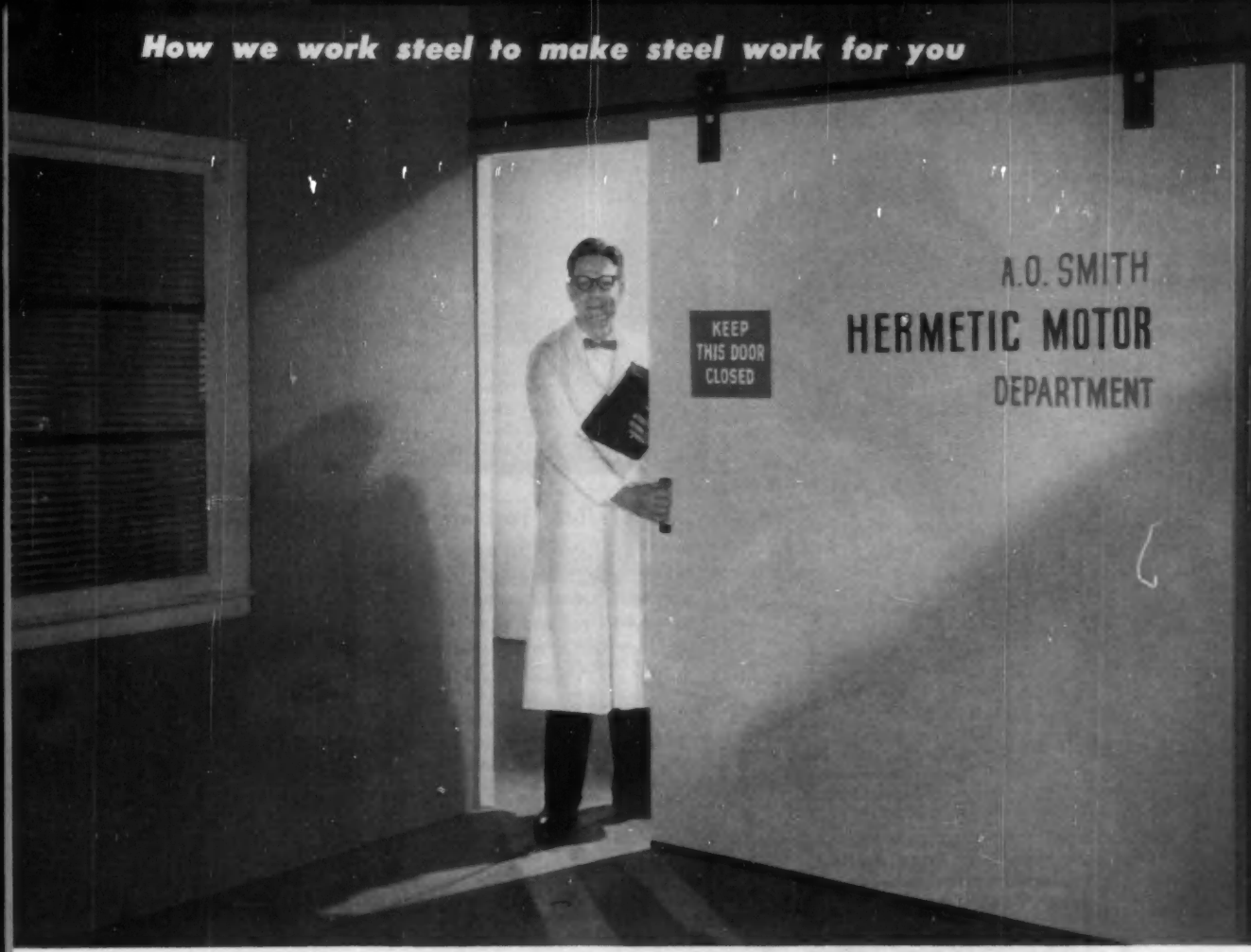

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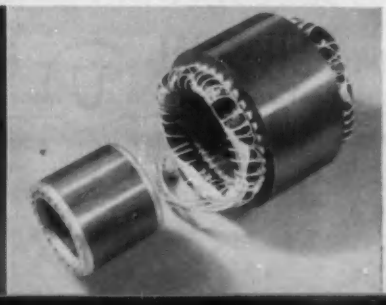

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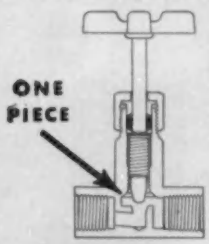

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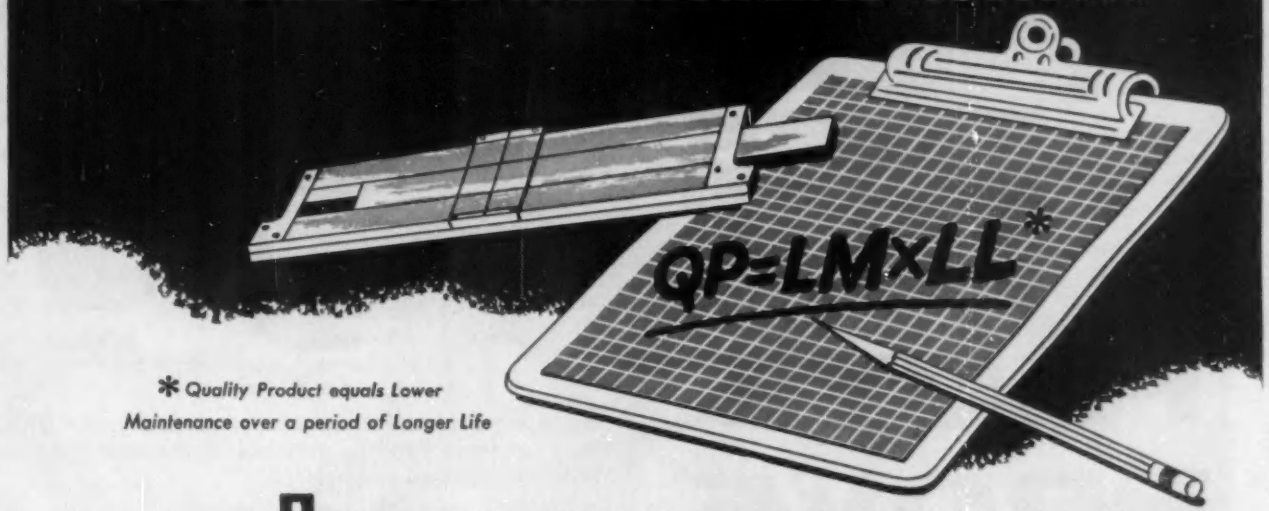

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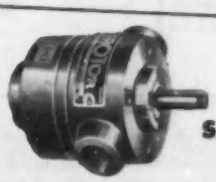


SERIES "QDB"

g.p.m. .4 to 1.5

PRESSURE—Maximum continuous operating pressure to 1000 p.s.i.

SPEED—Standard design speed is 1800 r.p.m. Specific recommendations are made for applications at other speeds.

ROTATION—Standard rotation is clockwise facing shaft end. Counter-clockwise rotation is available.

OIL—Hydraulic oils with viscosity of approximately 300 s.s.u. at 100° F. are recommended.

MOUNTING—Standard mountings are plain (weight 6½ lbs.), base (weight 8¼ lbs.) and flange (weight 9 lbs.).

SERIES "QDH"

g.p.m. 3 to 12

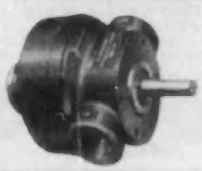
PRESSURE—Maximum continuous operating pressure is 1200 p.s.i., maximum intermittent 1500 p.s.i.

SPEED—Standard design speed is 1200 r.p.m. Specific recommendations are made for applications at other speeds.

ROTATION—Standard rotation is clockwise facing shaft end. Counter-clockwise rotation is also available.

OIL—Hydraulic oils with viscosity of approximately 300 s.s.u. at 100° F. are recommended.

MOUNTING—Standard mountings are plain (weight 28 lbs.), base (weight 32 lbs.) and flange (weight 31 lbs.).



SERIES "O"

g.p.m. 20 to 40

PRESSURE—Maximum continuous operating pressure is 1000 p.s.i., except for type 0-40, which is recommended for only intermittent duty at 1000 p.s.i. and 700 p.s.i. continuous.

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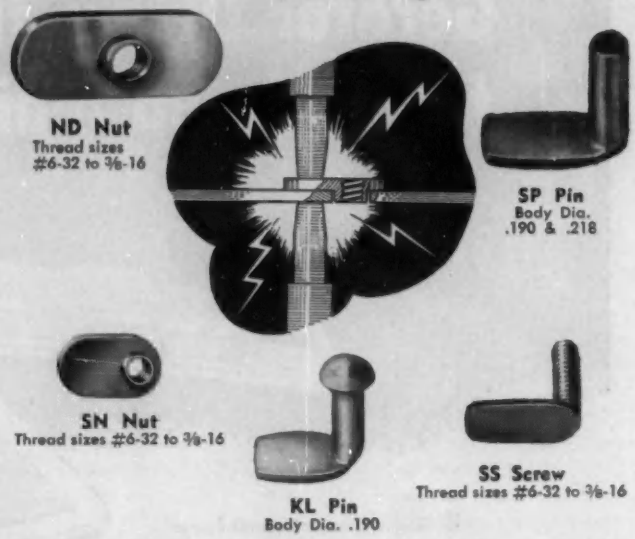

ND Nut
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Body Dia. .190 & .218

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Rolled 1" and under	.....	120,000	110,000	105,000	95,000	85,000
Rolled or Forged, over 1"	.....	115,000	108,000	100,000	90,000	85,000
Yield Point (divider method)						
Sand Cast	95,000	75,000	80,000	55,000	45,000	40,000
Rolled 1" and under	.....	75,000	65,000	60,000	50,000	45,000
Rolled or Forged, over 1"	.....	75,000	65,000	60,000	50,000	45,000
Elongation in 2"—%						
Sand Cast	10	12	14	15	20	25
Forged or Rolled	.....	12	13		15	20
Reduction in area—%						
Sand Cast	.....	12	14	15	20	25
Forged or Rolled	.....	12	13		15	20
COMPRESSION						
Yield Point— lbs. per sq. in.	70,000	65,000	58,000	50,000	40,000	35,000
Permanent Set at 100,000 lbs. per sq. in. (max.)	.015	.020	.030	.050	.080	.125
Brinell hardness, No.	250	240	220	200	175	150

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ARMY
Forgings, Rolled Rod QQ-B-721 Class B
Castings...QQ-B-726 Class B and C

NAVY
Forgings and Rolled Rod 46B15d Class B
Castings, Aluminum-manganese Bronze 46B29

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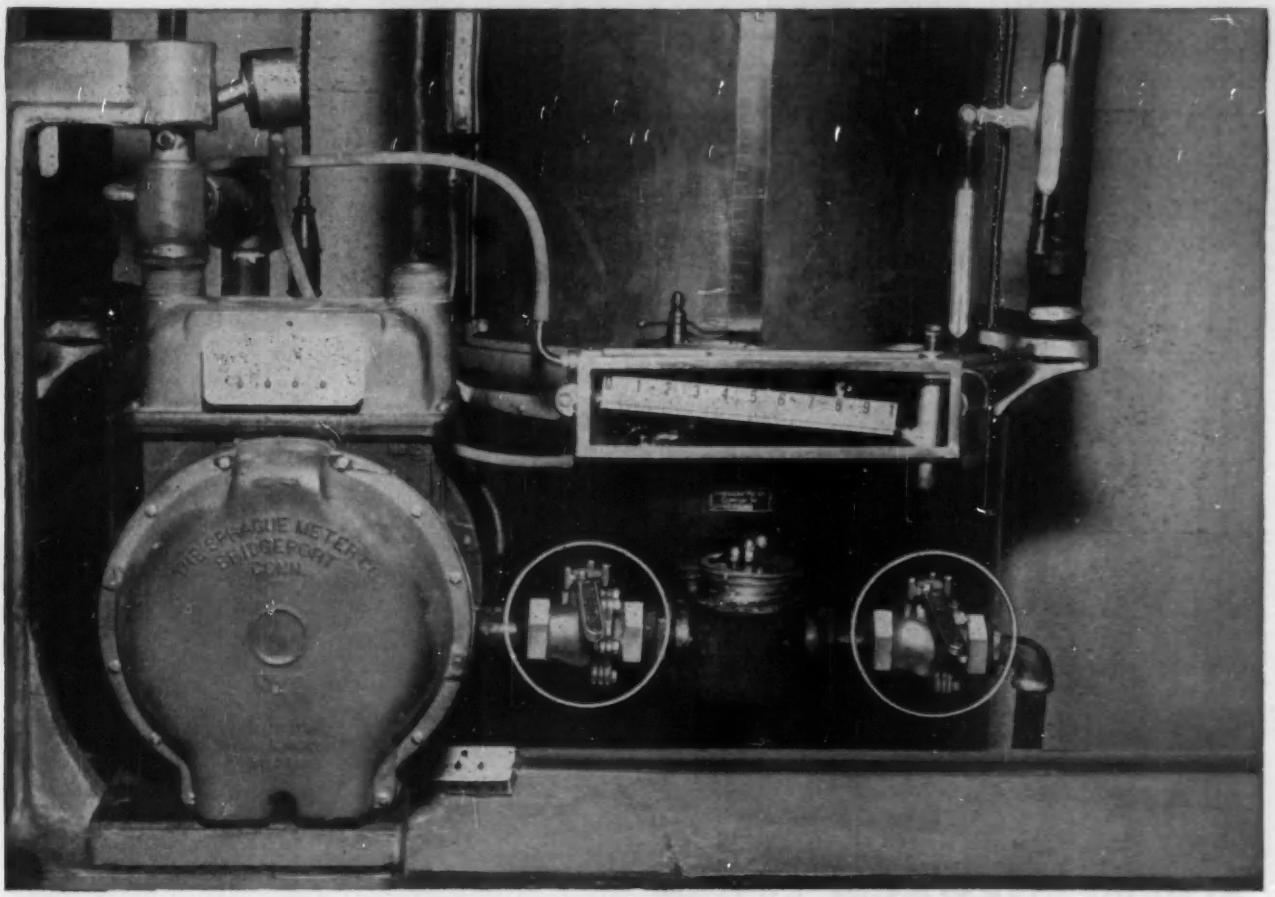

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CASE STUDY

DESIGNATION: Female Hinge

METAL USED: Stainless Steel (AISI 302)

QUALITY CONTROL: Chemical and physical affidavits furnished. Test Bars submitted. Produced with 100% X-Ray requirements.

PARTS: Designed and cast as single unit. Formerly composed of three units welded together.

ADVANTAGES: Strengthened with re-inforcing ribs in U-Bracket. Weight decreased without decrease in strength. Reaming holes only machining required. Formerly holes countersunk outer sides only, now cast with radii on both inner and outer sides. Greatly reduced cost.

ARWOOD

PRECISION CASTING CORP.

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PLANTS: Brooklyn, N. Y. • Groton, Conn. • Tilton, N. H. • Los Angeles, Calif.

Miniature A.C. 60 Cycle MOTOR with Planetary Gear Reducer

Constant Speed

High Output Torque

Long Life

Precision-built hysteresis-synchronous motor provides constant speed from no-load to maximum rated torque. Furnished for single phase capacitor-run operation for 1800 and 3600 RPM motor speed at 60 cps. Units are also available for 2 or 3 phase operation. Winding is for 115V A.C., and may be varied for special applications. Planetary gearing provides 18 standard speed reduction ratios from 18.78:1 to 21,808:1. Output torques range from 12 oz. in. to 1000 oz. in. Diameter 1¼". Length depends on ratio. Weight 9 to 12½ ozs. Service life up to 5000 hrs. Units meet military specifications. *Write for details today!*

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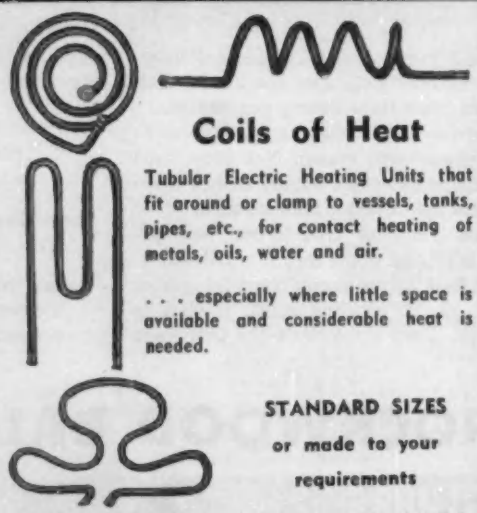
VULCAN

ELECTRIC HEATING UNITS



Coils of Heat

Tubular Electric Heating Units that fit around or clamp to vessels, tanks, pipes, etc., for contact heating of metals, oils, water and air.

. . . especially where little space is available and considerable heat is needed.

STANDARD SIZES or made to your requirements

VULCAN ELECTRIC COMPANY

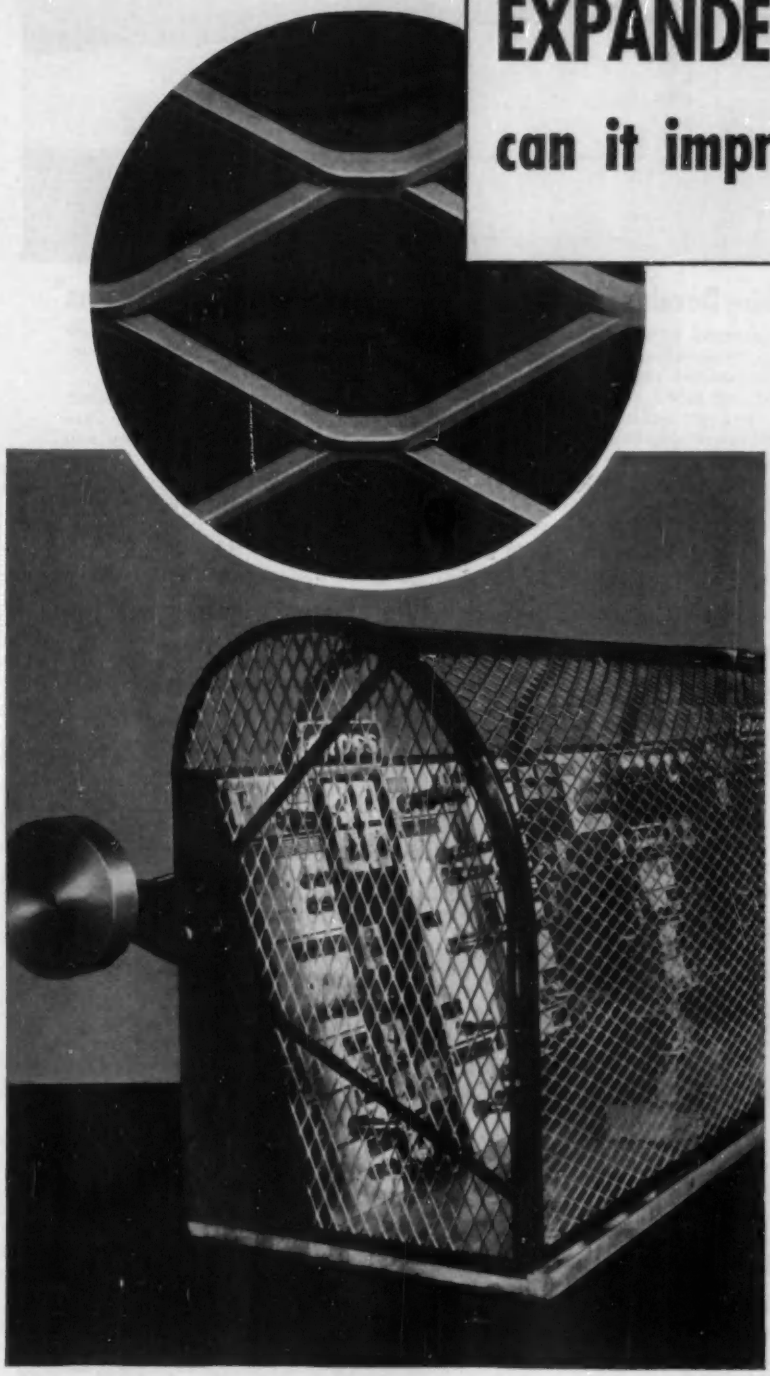
DANVERS 18, MASS.

Electric Heating Units. Electric Soldering Tools. Electric Solder Pots and Glue Pots. Electric Branding Irons.

See 8-page Vulcan catalog in Sweet's Product Design File for 1955

EXPANDED ALUMINUM...

can it improve your product?



Penmetal expanded aluminum is sheet aluminum, slit and expanded to as much as ten times its original width. As expanded metal, aluminum loses none of its valuable properties. Rather it gains a number of characteristics which make it ideally suited for application to an almost limitless variety of products.

Penmetal expanded aluminum is up to 80% lighter per square foot than the original sheet. Yet it is stronger and more rigid. It permits free passage of light and air, and has that smart, clean, attractive look that typifies modern trends in design.

Besides aluminum, expanded metal comes in carbon steel, stainless steel, Monel, Inconel, and other metals. Large or small mesh; light or heavy gauge. Easily formed, shaped and welded.

Send for new four-page folder which gives mesh sizes, weights and dimensions, and shows a number of profitable ways to use this versatile material.

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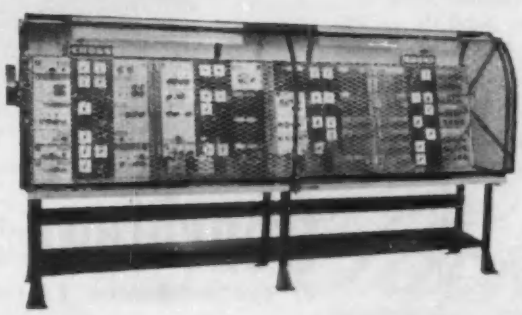
Plant: Parkersburg, W. Va.

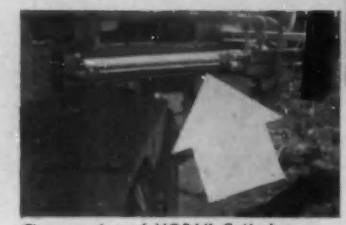


Expanded aluminum used to form a drum type guard over control and tool panel made by Cross Company, Detroit, Michigan.

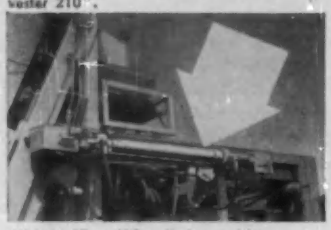
METAL MARK Penmetal 1869 OF QUALITY

PM-7B

Arrows show location of 2 NOPAK Cylinders.



Close-up view of NOPAK Cylinder which rotates superstructure of harvester 210°.



NOPAK 4" x 48" cylinder positions conveyor boom to suit field conditions.

*With the cooperation of NOPAK Hawaiian representative, Chapson Bros. Ltd., Honolulu.

PINEAPPLE HARVESTER
USES 5 NOPAK HYDRAULIC CYLINDERS

Unique Machine Developed in Hawaii by Libby, McNeil & Libby Engineers*

The pineapple harvester pictured is the result of continuing research and experimentation by the mechanical engineering staff of Libby, McNeil and Libby, in striving for better methods, more efficient machines, and lower costs in all operations from field and farm to packing and labeling.

While space does not permit a detailed description of their functions . . . 5 NOPAK Hydraulic Cylinders are used in this self-contained harvester to provide the power for various movements essential to its successful operation.

Power for machine motions . . . pulling, pushing, lifting, feeding, retracting . . . are provided in all kinds of machinery and equipment by NOPAK Cylinders . . . controlled by NOPAK Operating Valves. For a wide range of interesting installations, write for the NOPAK APPLICATION MANUAL.

GALLAND-HENNING NOPAK DIVISION
2762 SOUTH 31ST STREET • MILWAUKEE 46, WISCONSIN

Refer to Classified Section of your Telephone Directory for name of nearest NOPAK Representative.

Ask for NOPAK Cylinder Catalog 101 or Bulletin SW-3.

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VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

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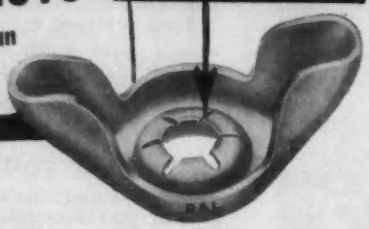
Vibration-proof
WING NUTS
cost less than ordinary types

Built-in spring locking action holds tight until finger-released



An extra value for your customers—a real saving for you. Precision, spring steel PALNUT Wing Nuts spin on freely—lock securely when finger-tightened—stay tight in service—unlock with finger removal. Sizes: #6-32, #8-32, #10-32, #10-24, ¼-20 and 5/16-18. Finishes: cadmium, nickel, chrome or others to order. Send for free samples, stating sizes required.

THE PALNUT CO., 65 Cordier St., Irvington 11, N. J.
In Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

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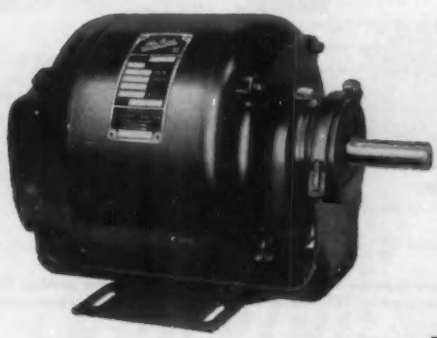
One Satisfied Customer tells another...



When women get together, appliances are bound to get into the conversation before long. Then one of a manufacturer's best salesmen—the satisfied customer—can really do a job for him. When the talk is about *Packard*-powered appliances, the job is done with extra enthusiasm—from sheer satisfaction.

For over 38 years Packard Electric motors have been giving dependable, low-cost service to users. The appliance maker who standardizes on Packard fractional horsepower motors benefits from the satisfaction they give, from enhanced reputation and from increased sales.

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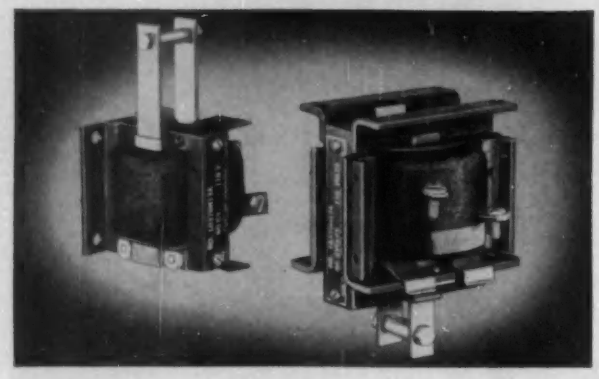
PROOF? **Long preferred by BIG NAME USERS**



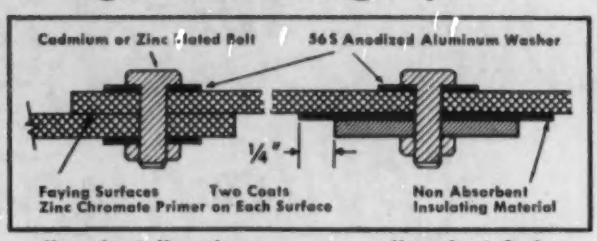
When unfailing dependability is a "must" in such electrically actuated devices as mechanical brakes, clutches, valves, tripping mechanisms, hydraulic pistons, ratchets, etc., insist on Cutler-Hammer Solenoids, Bulletin 10370. They are not ordinary solenoids. They are solenoids built to Cutler-Hammer standards of performance. For many years leading machinery manufacturers renowned for the fine performance and dependability of their machines have specified Cutler-Hammer Solenoids and refused all substitutes.

Cutler-Hammer Bulletin 10370 Solenoids are rated for continuous or intermittent duty. The coils are moisture-resistant, tung-oil impregnated, can be used immersed in non-acid or non-alkaline oil. The coils are held in place by flat steel springs that prevent transmission of shocks to the coils. Plungers and frames are carefully machined to insure quiet operation.

Use Cutler-Hammer Bulletin 10370 Solenoids whenever full rated power straight-line push or pull is required. Plungers are fitted with yoke or clevis connections to the work. Operation may be by a manual switch, pushbutton, pressure switch, float switch, limit switch, etc. Available in many sizes, for floor or wall mounting. Carried in stock by many Cutler-Hammer Authorized Distributors. Phone or write now for full information. Ask about Bulletin 10370. CUTLER-HAMMER, Inc., 1332 St. Paul Avenue, Milwaukee 1, Wisconsin.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Light metals design tips


Cadmium or Zinc Plated Bolt
565 Anodized Aluminum Washer
¼"
Faying Surfaces Zinc Chromate Primer
Two Coats on Each Surface
Non Absorbent Insulating Material
Magnesium to Magnesium—Normal Service
Magnesium to Steel—Normal Service

Tips on bolting magnesium to magnesium, to steel and to other metals

To join magnesium parts to each other or to steel or other metals, as shown above, cadmium or zinc plated steel bolts, anodized aluminum bolts or magnesium bolts may be used. Design-wise, a bolted joint employing magnesium members is the same as that used for other structural materials. Washers should be used when the bolt is not magnesium. Proper insulation of faying surfaces is equally important.

While magnesium may be tapped for studs and cap screws, longer threads are needed due to the low shear strength. For American Standard fine threads, thread engagement should be 2½ or 3 times the stud diameter; for coarse threads, 2 times the stud diameter is satisfactory.

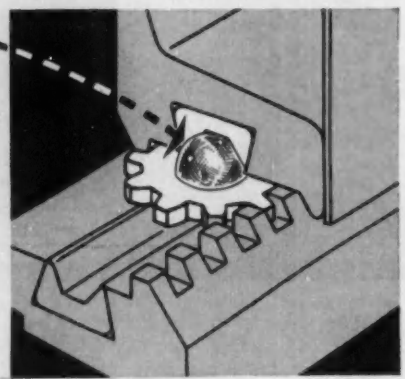
Normally, where parts are often dissembled, steel inserts are used to eliminate wear and also to guard against crossing the threads in the magnesium part. When spotfacing or counterboring, a .031" radius is required at the bottom of the cut for bolts up to 1¼" in diameter. Larger bolts require a .062" radius.

Help on specific light metals joining problems is available on request. In fact, whenever light metals can be used for your parts or products, Magcoa engineers can help you design them and Magcoa fabricating facilities can produce them for you. We welcome your inquiry.

MAGNESIUM COMPANY OF AMERICA
LIGHT METALS FABRICATION DIVISION • EAST CHICAGO 27, IND.

Another Example

of how Hartford makes Typewriters Function smoothly



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WHAT IS YOUR BEARING PROBLEM?

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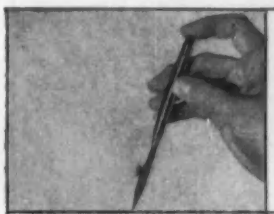
Save hours of finger-cramping manual erasing. Do a neater, safer erasing job. The patented hollow shaft permits use of extra-long, seven-inch eraser, prevents "fly-outs." These quiet, cool, vibration-free tools are permanently lubricated, require no maintenance.



"Rule-O-Matic" Ruling Pen
Eliminate the fuss, muss, and time of filling pens from bottled ink. Just a press of the finger, and a drop of ink flows from the cartridge in the hollow handle into the stainless steel nibs. A single catridge can rule up to 55,000 inches of a government approved India ink. Life-time guarantee.

Adjustable Triangle
Think of the time and work you'll save with this versatile drafting tool. It is fully adjustable from 45° to 90°. Reads to one-half degree. The engine divided protractor arc is beveled for quick, easy, precise settings. It is precision made of acrylic plastic for permanent clarity, long wear.

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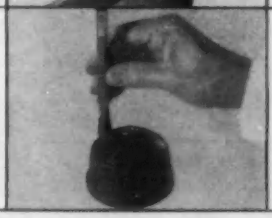
Now, get the work-saving advantages of a modern *scriber-type* lettering set . . . for less than ten dollars! Unique skid-proof runners keep the guide holder securely in position for perfect lettering. Three popular sizes of letters and numbers provide a versatile lettering combination.



"Tru Point" Pencil Lead Pointer
Save time and trouble with the most efficient and economical pencil pointer ever devised. You get a perfect concentric point to any degree of sharpness, and without breakage of lead in the pointer. Extra weight keeps pointer steady, lets you do pointing with one hand.

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We have been specializing in small-size socket screws for many years and have been making them by the millions in sizes down to No. 0 since 1950.

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BRISTOL'S

THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

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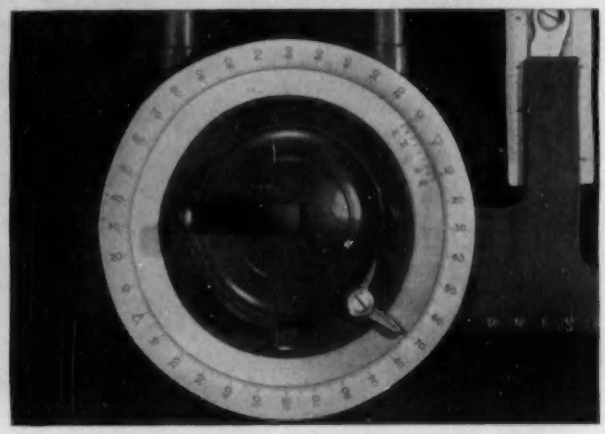
with Universal's Boardmaster...



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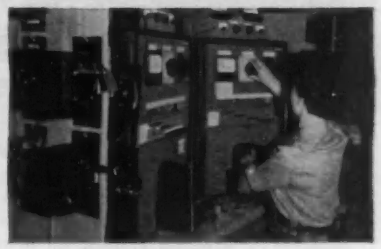
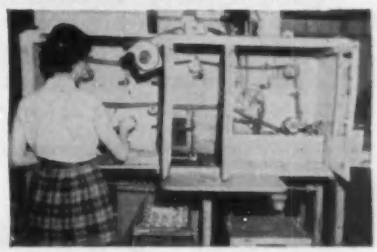
Automatic Hi-Pot tester developed by P&B



Ultrasonic Cleaning of relay assemblies



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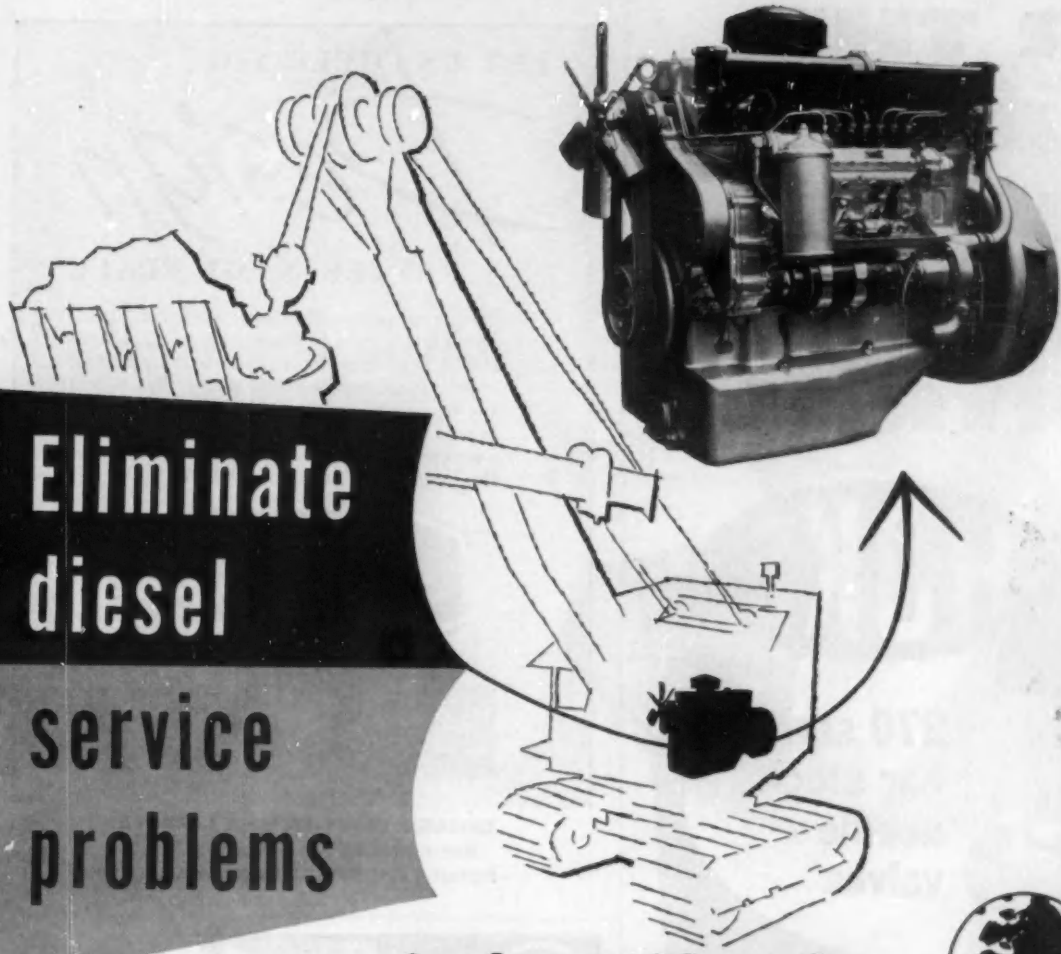

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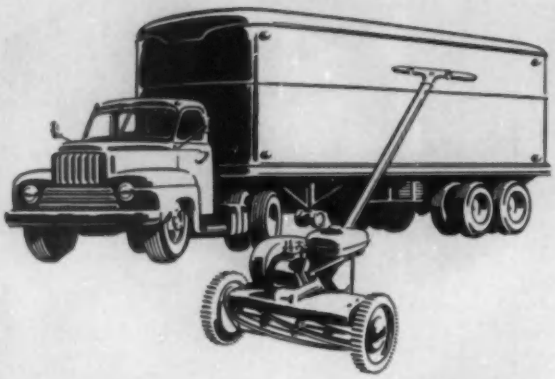

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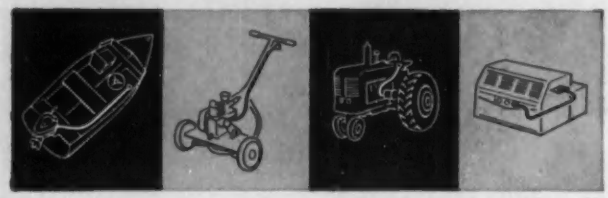

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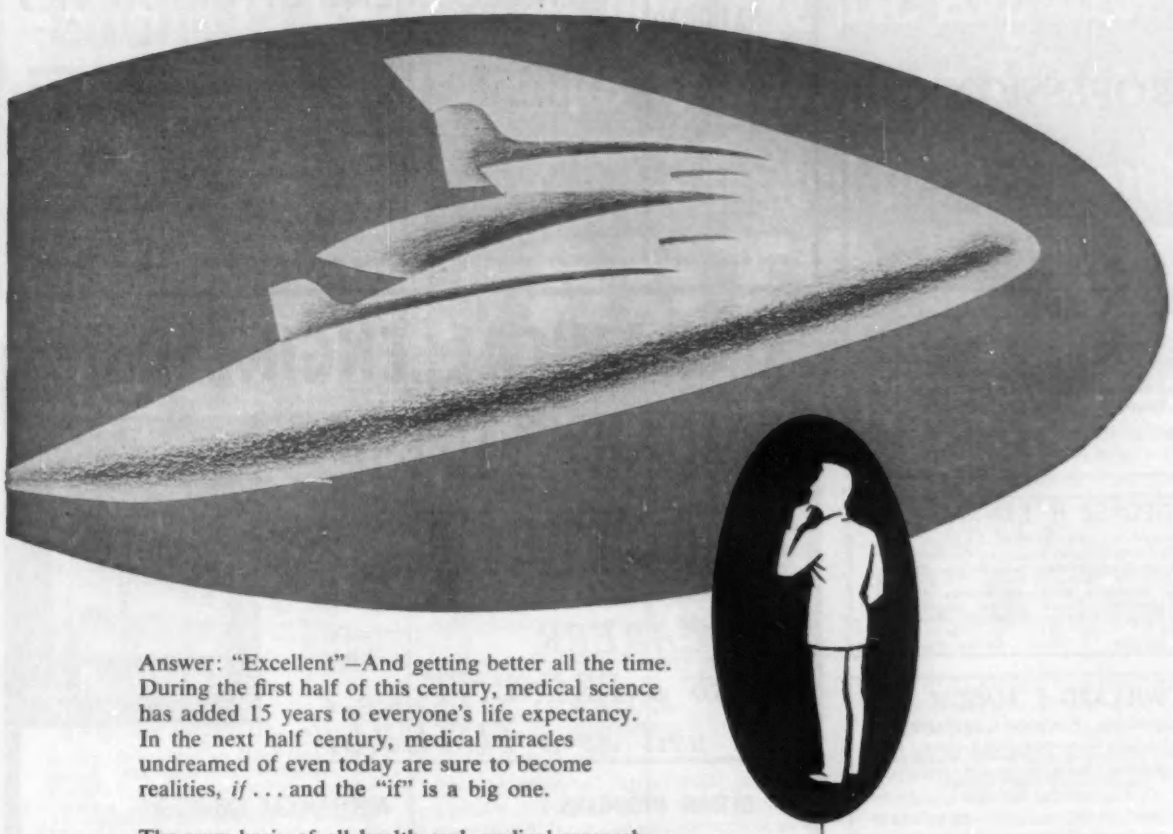

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- The National Fund is a voluntary, non-profit organization approved and supported by the American Medical Association and the Association of American Medical Colleges.

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*PRODUCT CONTROL ENGINEER

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MECHANICAL ENGINEER

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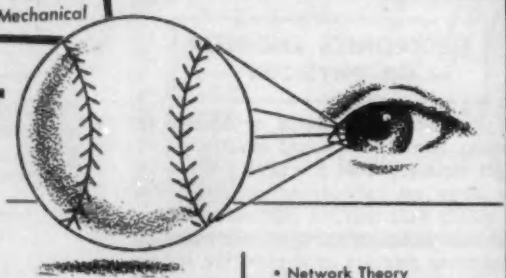

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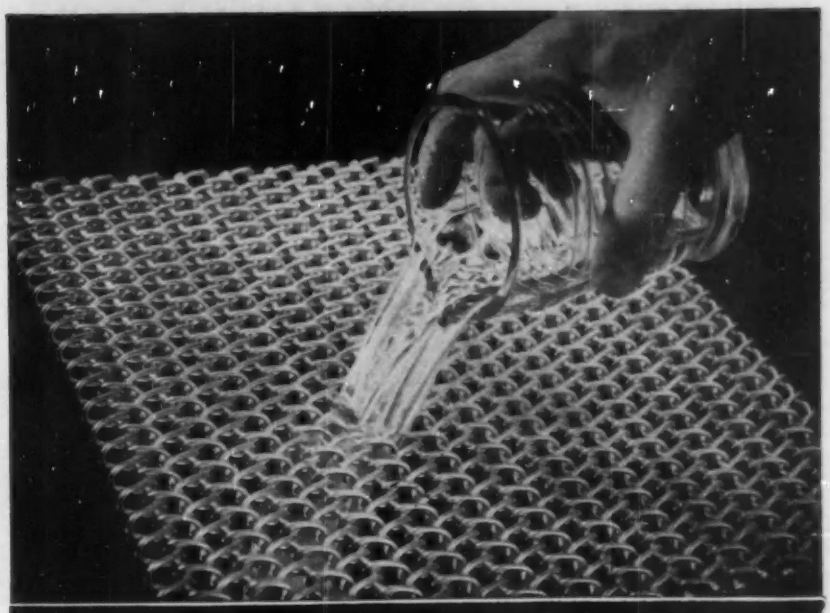

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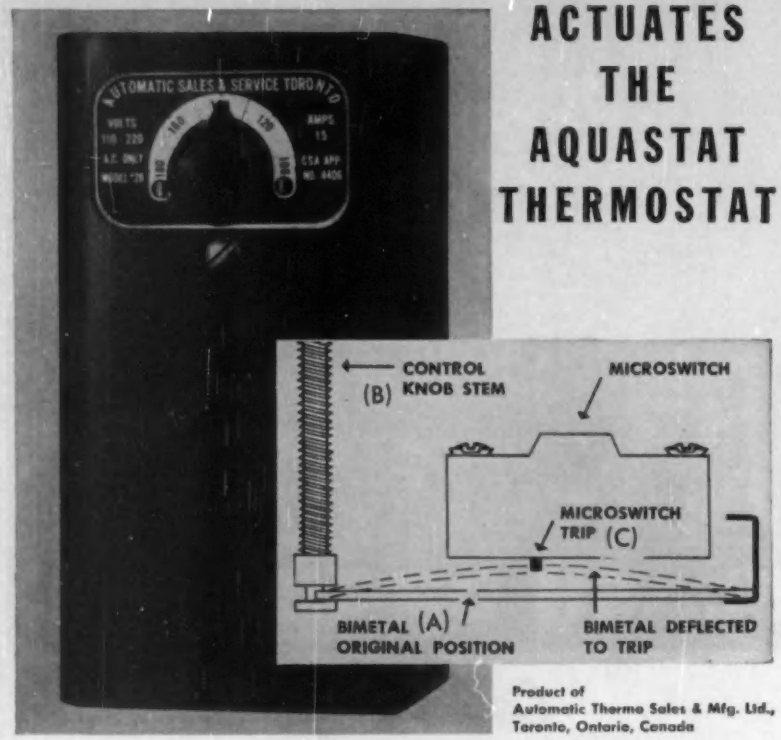

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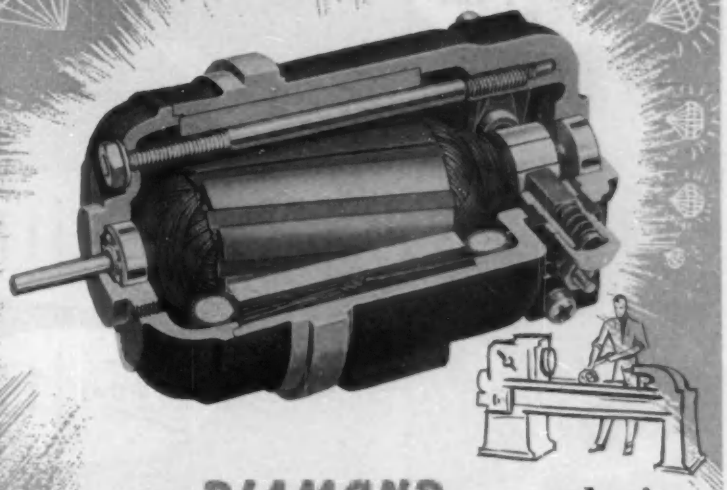

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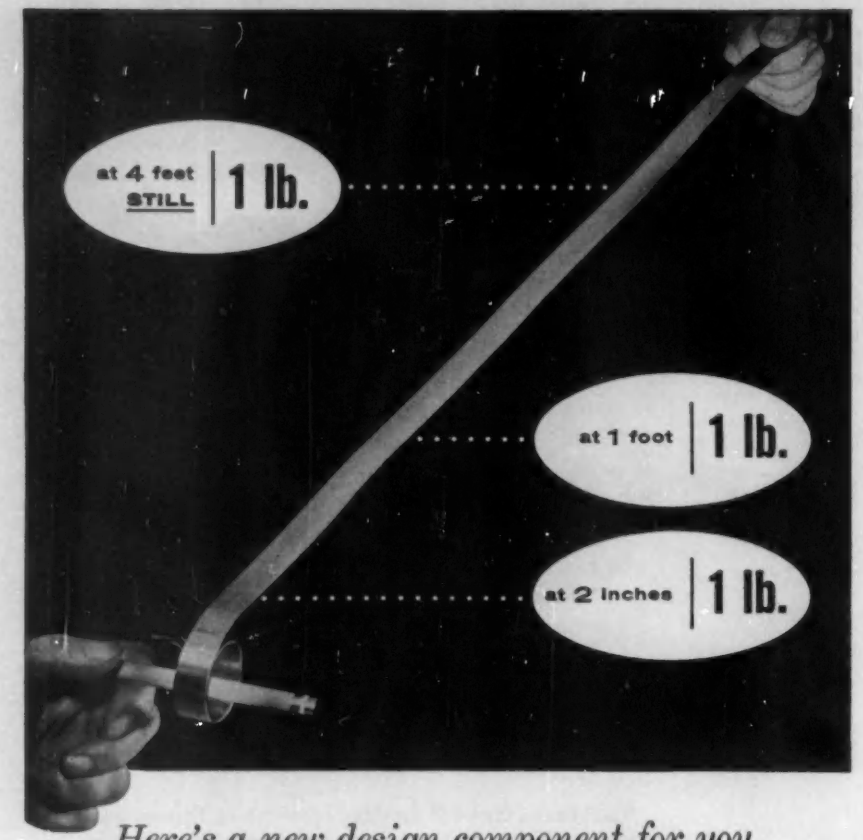

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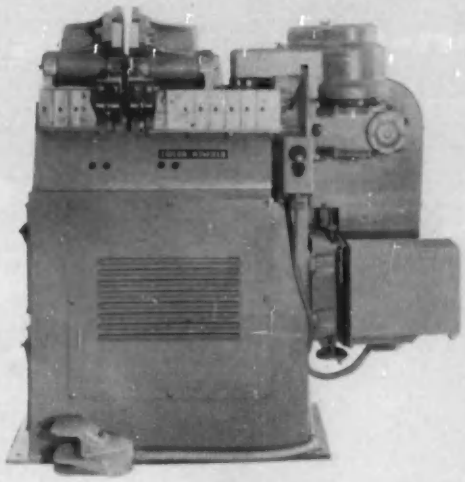

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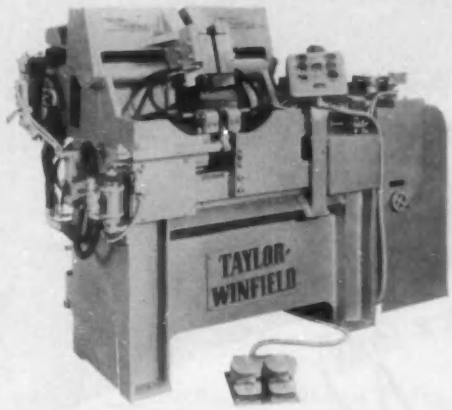

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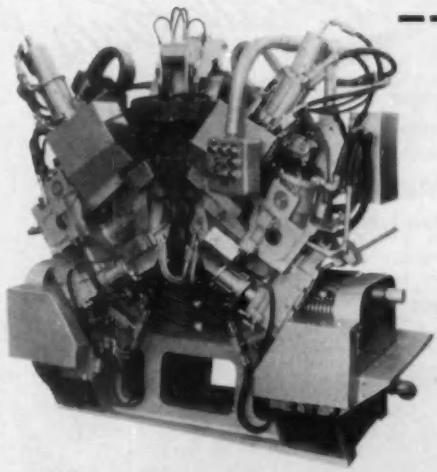

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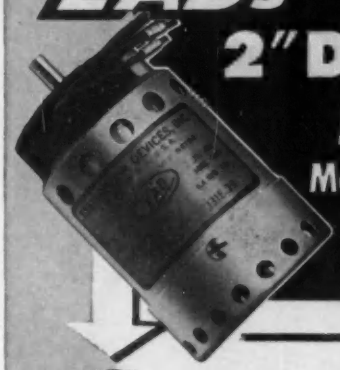
Makes Design easy as 1-2-3



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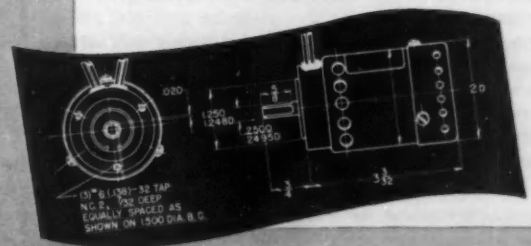
400 cycle 115 volts	1/100	7,200	0.30	P52QFU
	1/50	7,000	0.40	P52NFU
	1/30	6,200	0.80	P52LFU
	1/50	22,000	0.75	P50NDU
320-1200 cycle variable frequency	1/300	4,500 av.	0.60	P52UFU
	1/50	4,000	0.80	P52NEU

HYSTERESIS-SYNCHRONOUS: For timing devices; stroboscopic work; wherever load inertia is a problem (i.e. recorders, turntables, facsimile equipment, etc.)

	HP	RPM	AMPS	MODEL
60 cycle, 115 volts	1/200	3,600	0.26	P52SRU



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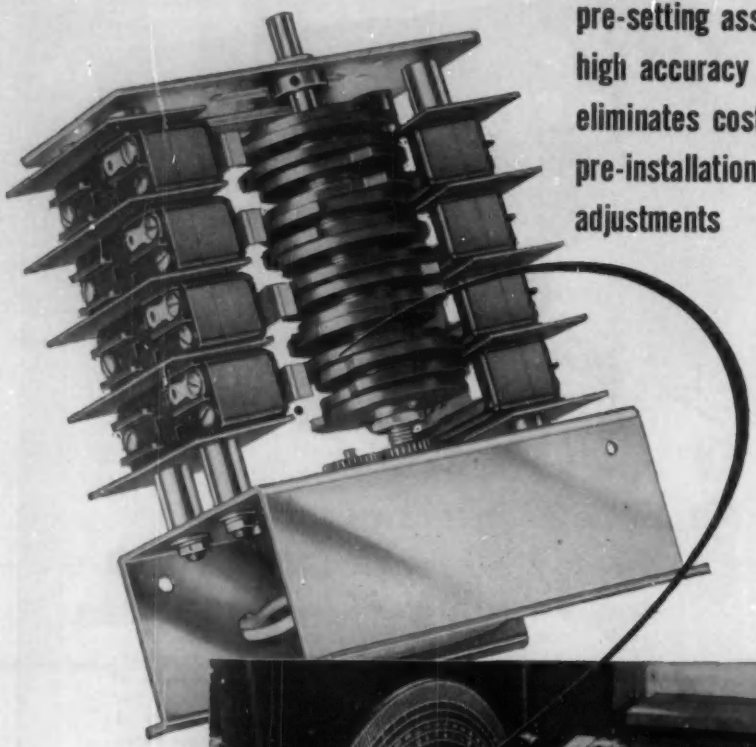
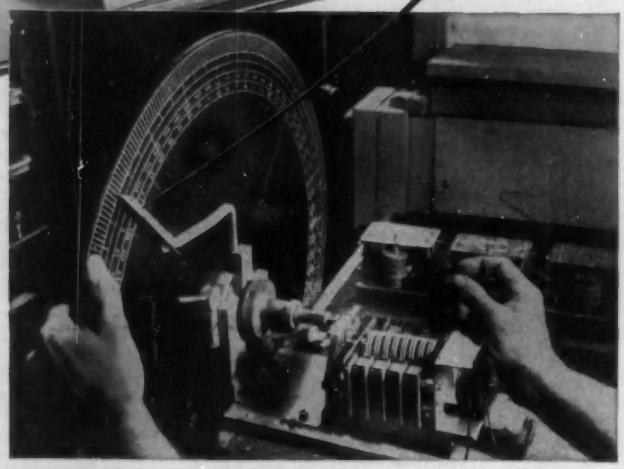


Factory pre-setting assures high accuracy . . . eliminates costly pre-installation adjustments



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The accuracy of a cycling timer depends on the exactness of the cam settings. If any one of the driving cams is incorrectly set, even to the minutest degree, the over-all program pattern or sequence of operations is changed.

Cramer cycling timers are normally supplied with all cams pre-set to customer specifications on special calibration equipment like that shown above. This pantographic principle, in effect, produces a sixteen-time enlargement of the cam, permitting extremely close setting accuracies.

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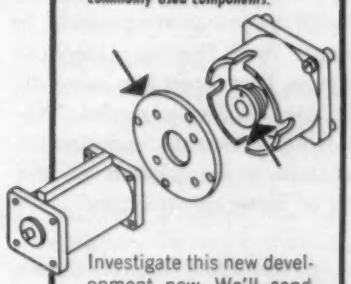

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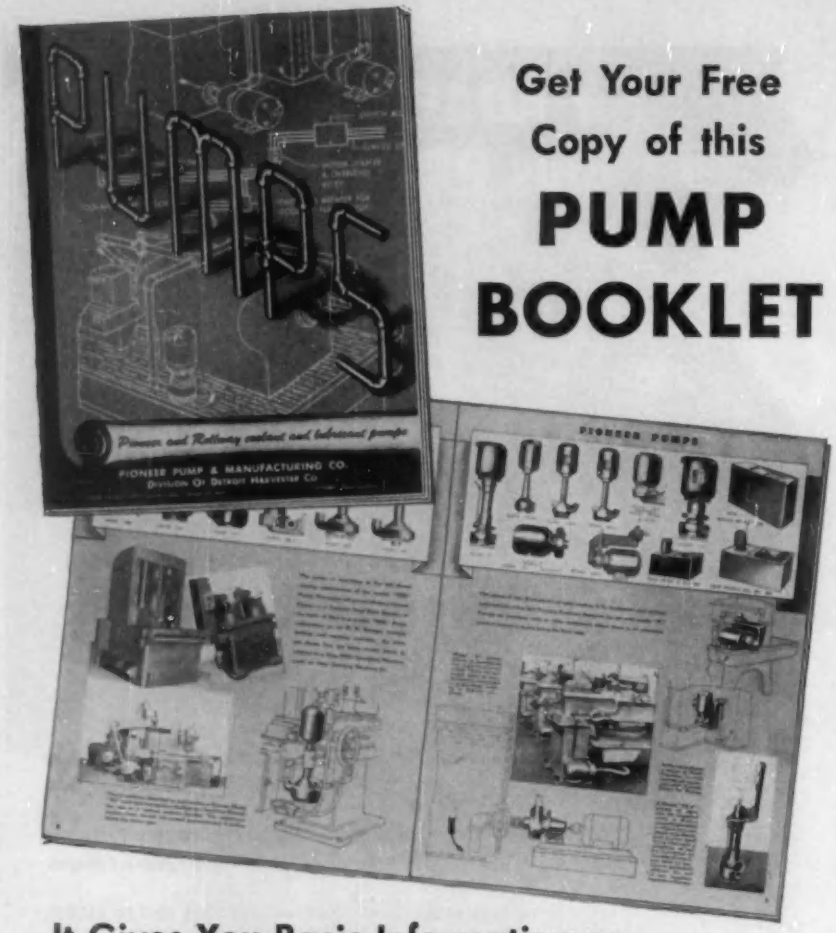

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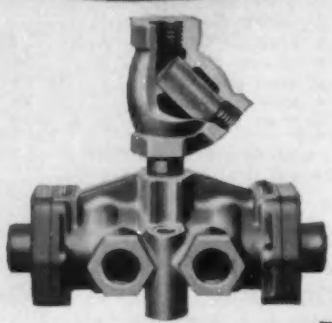

Model 6241
Air Control Valve

Cross-section view
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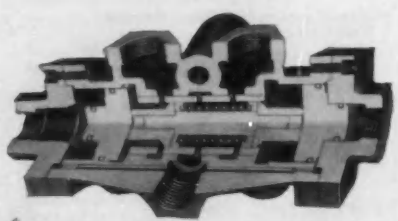

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83—Panel Meters
84—Blower Wheels
85—Pulse Oscillator
86—Indicating—Recording Tachometer
87—Miniature Axial Blowers
88—Sub-miniature Blower
89—Axial Flow Blowers
90—Reciprocating Booster
91—Pilot-Operated Relief Valve
92—Pneumatic Air Chambers
93—Manual Shut-Off Valve
94—Miniature Control Valve
95—High Pressure Valve
96—Adjustable Flow Regulator
97—Packless Solenoid Valve
98—Four-Way Rotary Air Valve
99—Three-way Valve and Pump
100—Filters, Oils and Regulates
101—Hydraulic Gear Pump
102—Magnetic Pipeline Traps
103—Airline Lubricator
104—Automatic Air Filter
105—Swiveling Coupling
106—Bulk Refill Filter
107—Chlorinated Polymer Rod
108—Insulation Also Controls Condensation
109—Sponge Vinyls
110—Roll-Formed Tube
111—Plastic Steel
112—Tempered Beryllium Copper Wire
113—Sheet Rubber Packing
114—Laminate for Printed Circuits
115—Moisture-Proof Containers
116—Magnifying Glass 2 in. Dia.
117—Reproduction to 46 in. Wide
118—Portable Drafting Machine
119—Ink In a Squeeze Bottle
120—Recording Oscillograph
121—Instrument Components Kit
122—Measures Vibration
123—Film for Whiteprint Process
124—Laboratory Pressure Transducer
125—Expanded Scale Frequency Meters

NEW BULLETINS . . . listed below are described on pages 282–291. Circle key number for your copy.

126—Ball and Roller Bearings
127—Potentiometer
128—Panel Meters
129—Vibration and Shock Mounts
130—Pneumatic Standards
131—Solenoid Valve
132—Electrical Plugs and Receptacles
133—Powder Metallurgy
134—Wire and Cable
135—Stainless Steel Wire
136—Switch
137—Compression Plugs
138—Electrical and Lubricating
139—Relays
140—Timers and Counters
141—Air Control Valves
142—Milliohmeters and Micrometers
143—Investment Castings
144—Plastic Steel
145—Stainless Steel Valves
146—Cooling Control
147—Deep Drawn Metal Boxes
148—Vibration Mountings
149—Long-Stroke Diaphragm
150—Hermetically Sealed Connectors
151—Rod End Bearings
152—Pipe Line Filters
153—Pumps
154—Thrust Retainers
155—Relays and Actuators

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NEW BULLETINS . . .

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SPECIFIC DATA . . .

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165—Variable Transformers
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168—Pneumatic-Hydraulic Systems
169—Drum, Foot & Limit Switches
170—Hydraulic Pumps
171—Induction Motor
172—Frequency Counter
173—Magnetic Ingot Iron
174—Adjustable Speed Drive
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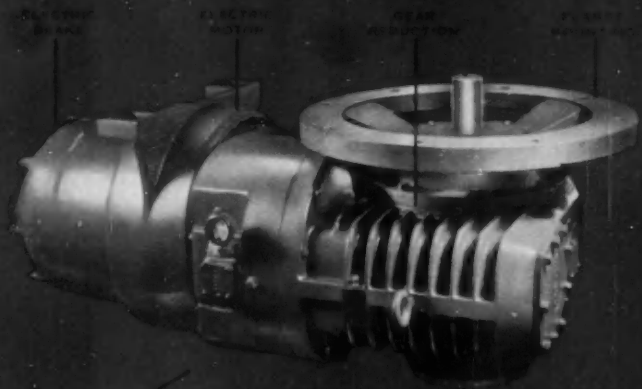

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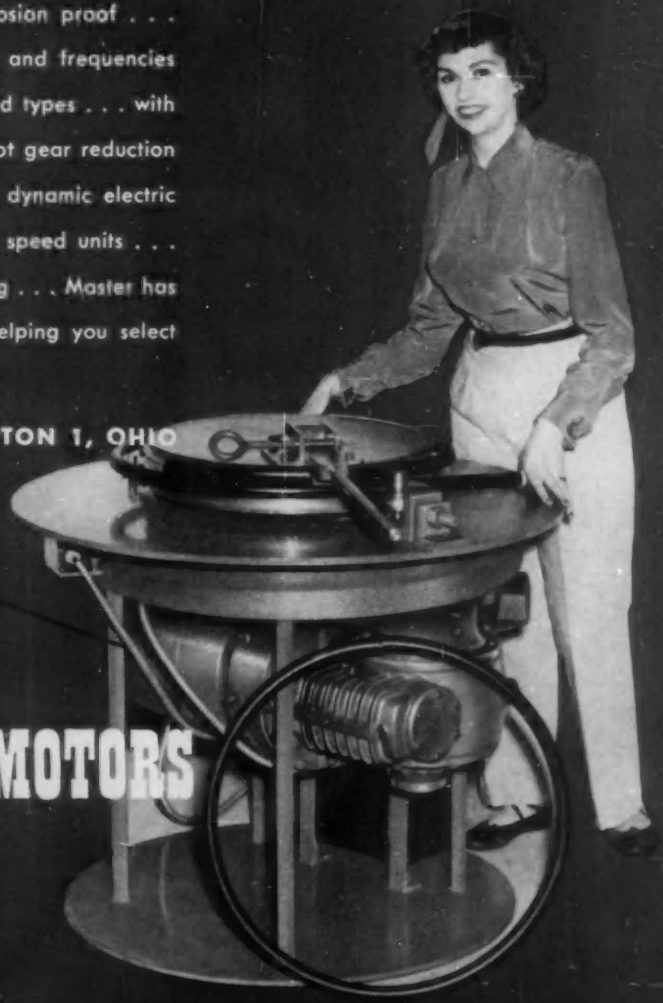
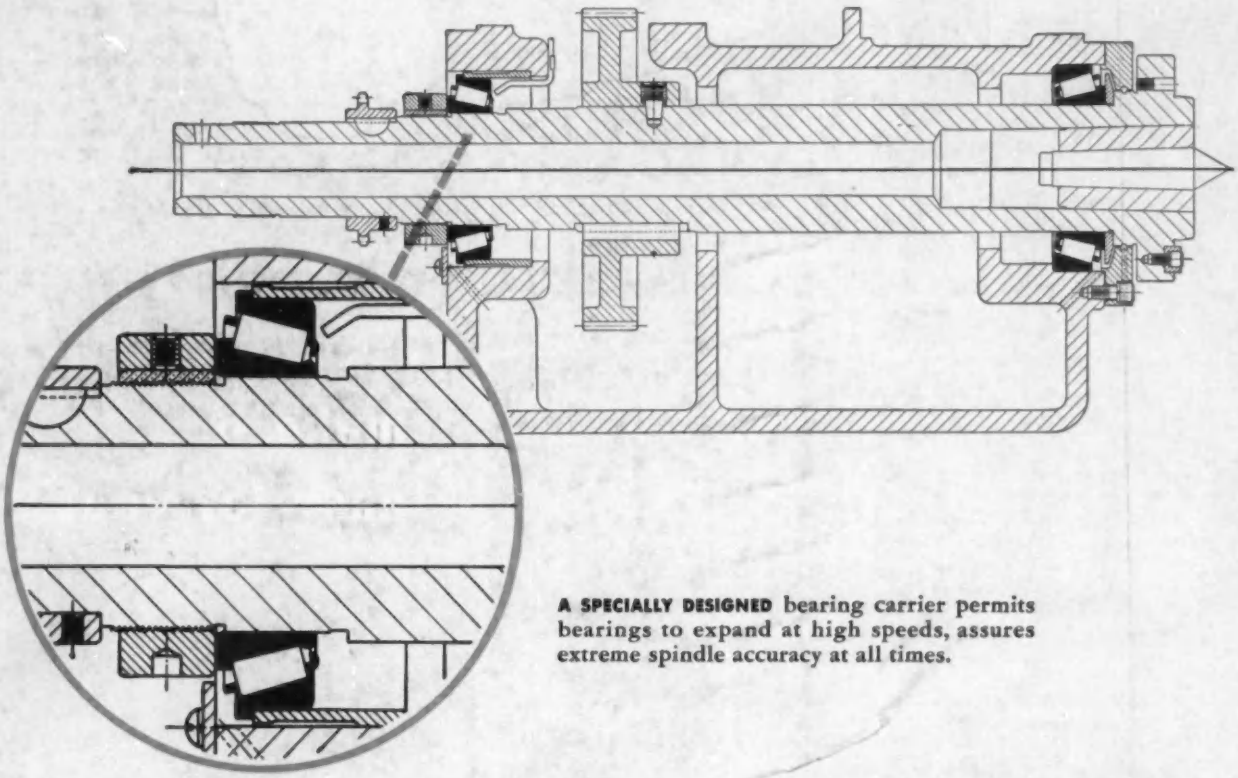


MASTER ELECTRIC MOTORS

How to maintain extreme spindle precision from low to very high speeds:

TIMKEN® bearings with semi-flexible mounting



A SPECIALLY DESIGNED bearing carrier permits bearings to expand at high speeds, assures extreme spindle accuracy at all times.

THE Timken Company has an ingenious solution to the problem of maintaining a high degree of spindle precision in machine tools. At high speeds, bearings expand. Normally this would cause the bearings in a precision mounting to tighten up and become excessively preloaded. But engineers at the Timken Company have developed a semi-flexible mounting. The rear spindle bearing is mounted in a special carrier. The carrier is designed to permit the rear bearing to expand radially while the entire spindle assembly expands longitudinally. As a result the desired bearing setting is maintained under all operating speeds. Extreme spindle accuracy is maintained at all times.

Timken® tapered roller bearings with these mountings have been applied to the spindles of many types of machine tools with great success. Of course not all machine tool spindles are required to operate at high speeds and over a variable range of speeds. The conventional Timken spindle mounting is entirely adequate for most machines.

Whatever your requirements, there are Timken tapered roller bearings to meet them. If not we'll find a new way, as we did when machine tool builders originally asked for precision bearings. And as we did when they asked for greater accuracy, which led to the famed Timken "O" and "OO" bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

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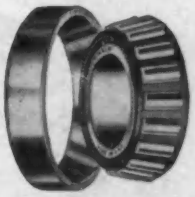

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